

**Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554**

In the Matter of)	
)	
Revision of Part 15 of the Commission's Rules)	ET Docket No. 13-49
To Permit Unlicensed National Information)	
Infrastructure (U-NII) Devices in the)	
5 GHz Band)	

SUPPLEMENTAL COMMENTS OF GLOBALSTAR, INC.

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EXECUTIVE SUMMARY

Since beginning commercial mobile satellite service (“MSS”) operations in 2000, Globalstar has shared the 5 GHz band with unlicensed indoor devices. This has been good policy, a fair balance between protecting licensed MSS and promoting the development of unlicensed services. While Globalstar does not oppose a higher power level for indoor devices, allowing outdoor unlicensed devices in this spectrum would upset this balance. This rule change would cause substantial harm to Globalstar and its customers.

To describe this harm, Globalstar submits into the record an independent technical analysis from Roberson and Associates, LLC. This detailed study shows that the operation of millions of outdoor U-NII-1 access points would drain Globalstar’s satellite power, diminish user capacity, and create gaps in signal coverage. Globalstar’s customers would experience this harm not only in the United States, but also in Mexico and Canada.

This outcome is directly contrary to the Commission’s fundamental obligation to protect licensed services from interference. Certainly, if the Commission permits outdoor operations in the U-NII-1 band, it will be very difficult to “put the genie back in the bottle” when these unlicensed devices cause harm to Globalstar’s satellite services. No party in this proceeding has described an effective way to mitigate harmful interference from potentially millions of unlicensed access points operating outdoors on Globalstar’s licensed feeder link frequencies. In reliance upon its existing licensed spectrum, Globalstar has spent more than \$1 billion to deploy its second-generation MSS constellation and fully restore its duplex capabilities, and a decision to allow U-NII-1 outdoor operations would jeopardize this investment.

This interference to Globalstar’s licensed MSS operations would have real public safety consequences. Globalstar’s MSS network has critical public safety uses that cannot be matched

by terrestrial systems. Globalstar's MSS system provides emergency communications connectivity to rural and remote areas, and has played a key role following Hurricanes Sandy and Katrina and other disasters when terrestrial networks have been down. Globalstar is poised to expand its public safety offerings and other two-way services now that its second-generation constellation is fully operational, but outdoor operations in the U-NII-1 band would threaten these plans.

The Commission should reconsider its U-NII-1 proposal and protect an established licensee and its customers from harmful interference. The Commission should maintain its existing prohibition on outdoor transmissions in the U-NII-1 band.

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Globalstar, Inc. (“Globalstar”) hereby supplements the record in the Federal Communications Commission’s (“FCC’s” or “Commission’s”) above-captioned proceeding on its rules governing the use of the 5 GHz band by Unlicensed National Information Infrastructure (“U-NII”) devices.¹ With this supplement, Globalstar provides a detailed, independent technical report demonstrating that the operation of outdoor U-NII-1 access points would have a substantial detrimental impact on Globalstar’s licensed two-way (duplex) mobile satellite services (“MSS”), both inside and outside the United States. Consistent with its rules and policies protecting licensed services from harmful interference from unlicensed operations, the Commission should maintain its prohibition on the outdoor operation of unlicensed devices in the U-NII-1 band.

¹ See *Revision of Part 15 of the Commission’s Rules to Permit Unlicensed National Information Infrastructure (U-NII) Devices in the 5 GHz Band*, Notice of Proposed Rulemaking, 28 FCC Rcd 1769 (2013) (“*NPRM*”).

I. GLOBALSTAR'S GLOBAL MSS NETWORK

Globalstar, licensed in 1995 to operate in the Big LEO band, is a leading provider of global mobile satellite voice and data services. With over \$5 billion invested in its global non-geostationary (“NGSO”) MSS network, Globalstar is fully committed to the continued development and future success of its satellite business. Globalstar uses its constellation of satellites and ground stations on six continents to provide affordable, high-quality MSS to more than 550,000 customers in over 120 countries around the world. Globalstar is licensed for uplink transmissions (mobile earth stations to satellites) in the Lower Big LEO band at 1610-1618.725 MHz, and for downlink transmissions (satellites to mobile earth stations) in the Upper Big LEO band at 2483.5-2500 MHz.² For its feeder links, Globalstar is authorized for uplink transmissions between its gateway earth stations and space stations in the 5096-5250 MHz band, and for downlink transmission from its satellites to its gateway facilities at 6875-7055 MHz.³

In February 2013, Globalstar successfully completed the launch campaign for twenty-four second-generation satellites. With a fifteen-year design life, Globalstar’s second-generation MSS system will support highly reliable, crystal-clear CDMA-quality voice and data satellite services to the millions of consumers, public safety personnel, and other potential customers covered by the new network beyond 2025. In offering an array of services to customers

² Iridium is authorized to share spectrum with Globalstar at 1617.775-1618.725 MHz.

³ See *Globalstar Licensee LLC, Application for Modification of Non-geostationary Mobile Satellite Service Space Station License*; *GUSA Licensee LLC, Applications for Modification of Mobile Satellite Service Earth Station Licenses*; *GCL Licensee LLC, Applications for Modification of Mobile Satellite Service Earth Station Licenses*, Order, 26 FCC Rcd 3948, ¶¶ 2 n.1, 3 (2011) (DA 11-520) (“*Globalstar 2011 Modification Order*”). Globalstar’s earth station in Clifton, Texas also utilizes the 5091-5092 MHz band for uplink transmissions to its space stations.

throughout the world, Globalstar's satellite network will provide the highest voice quality, fastest truly mobile data speeds, and most affordable service in the MSS industry.

II. INDEPENDENT TECHNICAL ANALYSIS: OPERATION OF OUTDOOR ACCESS POINTS IN THE U-NII-1 BAND WOULD HAVE A SUBSTANTIAL DETRIMENTAL IMPACT ON GLOBALSTAR'S MSS NETWORK

In the *NPRM*, the Commission proposed to eliminate the existing prohibition on outdoor operation of unlicensed devices in the U-NII-1 band, as well as raise the power limits in this band to levels permitted in either the U-NII-2A band or U-NII-3 band.⁴ Globalstar previously filed comments indicating that it does not oppose the U-NII-2A power level for indoor U-NII-1 operations, representing a five hundred percent power increase for these indoor devices.⁵ Globalstar opposed outdoor operations in the U-NII-1 band, however, and described the significant harm that such outdoor use would cause to Globalstar's MSS network.⁶ Now, Globalstar submits into the record an independent technical study from Roberson and Associates, LLC (the "Roberson Analysis"), which demonstrates in greater detail that a new rule permitting unlicensed outdoor transmissions in the U-NII-1 band would have a substantial detrimental

⁴ Under the Commission's "U-NII-2A" proposal, the power limits in the U-NII-1 band would increase from 50 mW to 250 mW with a maximum EIRP of 30 dBm with 6 dBi antenna gain, and permitted peak power spectral density would increase from 4 dBm/MHz to 11 dBm/MHz. Under the "U-NII-3" proposal, the U-NII-1 power limits would increase from 50 mW to 1 W with a maximum EIRP of 36 dBm with 6 dBi antenna gain, and the permitted peak PSD would increase from 4 dBm/MHz to 17 dBm/MHz.

⁵ See Comments of Globalstar, Inc., ET Docket No. 13-49, at 6 n.18 (May 28, 2013) ("Globalstar Comments"). As Globalstar indicated in its comments, any interference to its MSS operations resulting from this increased power level should be manageable. If the Commission takes this action, however, it will have to account for the increased noise level in Globalstar's feeder uplink spectrum if in the future a co-primary aeronautical radionavigation operator seeks authority to provide service in the United States. See Recommendation ITU-R S.1432-1, "Apportionment of the allowable error performance degradations to fixed-satellite service (FSS) hypothetical reference digital paths arising from time invariant interference for systems operating below 30 GHz" (Geneva, 2006), <http://www.itu.int/rec/R-REC-S.1432-1-200601-I/en>.

⁶ Globalstar Comments at 4-7.

impact on Globalstar’s licensed MSS operations.⁷ The Roberson Analysis describes the effect of the proposed U-NII-1 rule changes on Globalstar’s MSS feeder uplink at 5150-5250 MHz and, in turn, on Globalstar’s provision of MSS to its customers. The Roberson Analysis also invalidates the analysis and conclusions reached in the technical report filed by the National Cable & Telecommunications Association (“NCTA”) in its July 24, 2013 Reply Comments.⁸

As described in the Roberson Analysis, permitting outdoor operations would likely result in the deployment of millions of unlicensed outdoor access points in the U-NII-1 band.⁹

Commercial entities have publicly stated their intent to deploy numerous outdoor access points,¹⁰ and there is a high likelihood of competing, nationwide deployments of such access points by

⁷ See Attachment A, *Impact of Proposed U-NII-1 Rule Changes on Globalstar Operations*, Roberson and Associates, LLC, Chicago, Illinois (Nov. 29, 2013) (“Roberson Analysis”), filed herewith pursuant to a request for confidential treatment under the Commission’s rules. A redacted version is being filed in the record.

⁸ *Toward Expanded Wi-Fi Access in the 5 GHz Band*, Rob Alderfer, CableLabs, Dirk Grunwald and Kenneth Baker, University of Colorado (“CableLabs Report”), attached to Reply Comments of the National Cable & Telecommunications Association (“NCTA”), ET Docket No. 13-49 (July 24, 2013) (“NCTA Reply Comments”).

⁹ According to the Roberson Analysis, access point power levels are typically much higher than end-user device power levels and are expected to be the primary source of potential interference to Globalstar’s MSS network. Roberson Analysis at 2, 6-7.

¹⁰ For instance, Comcast has stated that it is “rolling out a new neighborhood hotspot initiative that has the potential to add millions of additional Wi-Fi access points throughout our footprint,” and that “all of our outdoor access points – and all the outdoor access points installed by our cable partners – include the ability to access the 5 GHz band.” *Id.* at 7, citing *Testimony of Thomas F. Nagel, Senior Vice President, Comcast Corporation, Before the U.S. House Committee on Energy and Commerce, Subcommittee on Communications and Technology, Hearing on “Challenges and Opportunities in the 5 GHz Spectrum Band,” November 13, 2013*, at 4, <http://docs.house.gov/meetings/IF/IF16/20131113/101359/HHRG-113-IF16-Wstate-NagelT-20131113-U1.pdf>.

multiple operators.¹¹ With no proposed limit on the number of outdoor deployments in this portion of the 5 GHz band, an uncontrolled proliferation of U-NII-1 access points could over time result in the operation of tens of millions of these transmitters. The Roberson Analysis conservatively assumes the deployment of 4.4 million access points throughout the U-NII-1 band, on the basis of a representative access point deployment by Google in Mountain View, California.¹² The Roberson Analysis also assumes unlicensed access point characteristics based on real-world observations of access point deployments and operations (*see* Roberson Analysis at Appendix B),¹³ and incorporates operating characteristics for Globalstar’s global MSS network that are consistent with information that Globalstar has previously filed with the Commission.

Based on these assumptions, the Roberson Analysis describes the negative impact of the projected outdoor access point deployment in the U-NII-1 band on Globalstar’s MSS operations. First, with outdoor U-NII-1 signals avoiding attenuation by the walls and ceilings of buildings,

¹¹ Roberson Analysis at 6-7. As the Roberson Analysis points out, it appears that some commercial entities are proposing outdoor deployments of unlicensed access points in order to augment or even replace wide-area 4G cellular service.

¹² Roberson Analysis at 7. Google’s Wi-Fi deployment in Mountain View yields an access point density of 16 access points per square kilometer.

¹³ *Id.* at 8-9, 35-37. Representative technical parameters for U-NII-1 access points include deployment of access points at a height of 5-8 meters, the use of 6 dB gain antennas, an elevation angle of 30 degrees to Globalstar’s NGSO satellites, and a peak hour duty cycle of 100%. As the Roberson Analysis explains, in assessing the effect of outdoor U-NII-1 operations on Globalstar’s MSS system, it is appropriate to focus on peak hour operations, when use of U-NII-1 access points as well as Globalstar’s MSS network is at its highest level. The Roberson Analysis assesses the impact of U-NII-1 operations on Globalstar’s MSS network assuming these representative access point parameters, and also considers how variation in these parameters would change this projected impact. In particular, the Roberson Analysis accounts for different access point duty cycles and evaluates the effects of varying levels of urban “clutter” and building shadowing. With respect to duty cycles, the Roberson Analysis states that a 50% duty cycle is unlikely during peak traffic periods and identifies it as providing “a lower bound on the effect that unlicensed access points will have on Globalstar operations.” *Id.* at 9.

the Roberson Analysis demonstrates that aggregate emissions from outdoor U-NII-1 access points operating at 5170-5250 MHz would cause substantial interference to Globalstar's MSS feeder uplink.¹⁴ Each Globalstar satellite has a feeder link antenna that "hears" all U-NII-1 transmissions within its feeder link coverage area, which is approximately 5800 km in diameter. The Roberson Analysis shows that at U-NII-2A power levels, the operation of 4.4 million unlicensed outdoor U-NII-1 access points would collectively cause a level of interference to Globalstar's MSS feeder uplink that far exceeds the ITU-R's Recommendation for allowable interference levels to low earth-orbit satellite links.¹⁵ In fact, this interference to Globalstar's feeder uplink would exceed the ITU-R's recommended level by as much as 27 dB. Operations at U-NII-3 power levels would have an even greater impact, likely resulting in interference 33 dB higher than the ITU-R Recommendation.¹⁶

Contrary to the CableLabs Report's claims, the Roberson Analysis demonstrates that this harmful interference to Globalstar's licensed MSS feeder uplinks would have substantial detrimental effects on Globalstar's duplex service downlink to end users in the 2483.5-2500 MHz band.¹⁷ First, this uplink access point interference would have an unavoidable impact on the available radiofrequency ("RF") power on Globalstar's satellites. Assuming the operation of

¹⁴ Roberson Analysis at 9-11.

¹⁵ Recommendation ITU-R S.1426 established a level of acceptable interference that can be tolerated by Fixed Satellite Service feeder uplinks for NGSO MSS systems.

¹⁶ Roberson Analysis at 9-10, 30-31. Interference to Globalstar's MSS feeder uplink would likely exceed the ITU's recommendation by even greater margins if the number of outdoor access points exceeded 4.4 million.

¹⁷ CableLabs Report at 17. As Globalstar has previously explained, Globalstar's feeder uplinks from its gateway earth stations carry the "return" traffic from parties communicating with Globalstar's MSS users, and Globalstar's satellites then translate, amplify, and downlink this return traffic to its MSS customers in the Upper Big LEO band at 2483.5-2500 MHz.

4.4 million access points across the U-NII-1 band, the downlink retransmission of uplink interference plus automatic CDMA-based power increases¹⁸ would consume up to 37% of the available satellite RF power on Globalstar's licensed satellites.¹⁹ Deployed satellites have a finite power supply, and the allocation of significant power resources to the retransmission of interference would mean that less satellite power is available to carry user traffic and perform other system functions. Overall, this "waste" of satellite power would reduce the user capacity of Globalstar's MSS network by a corresponding 37%, potentially resulting in busy signals and failed call attempts for Globalstar customers throughout North America.²⁰ If more than 4.4 million outdoor access points were deployed in the U-NII-1 band, there would be an even greater "waste" of satellite power and a greater corresponding decrease in capacity. Such capacity reductions in North America would not only affect Globalstar's current services, they could impose future constraints on Globalstar and limit the growth and development of its services in this region.²¹

¹⁸ Roberson Analysis at 21, 23. Since Globalstar's CDMA downlink user channels employ closed loop power control, user transmit power is increased to maintain user call quality. This additional RF power consumption and the downlink retransmission of uplink interference are both unavoidable effects.

¹⁹ This impact on satellite power availability assumes the representative access point parameters that the Roberson Analysis considers most likely (*see* note 13 *supra*). Even where the Roberson Analysis introduces variation in these parameters, the effect on Globalstar's MSS operations is still significant. Roberson Analysis at 21-23.

²⁰ Roberson Analysis at 23. The impact on Globalstar's MSS downlink would also be greater if the Commission permitted U-NII-1 devices to operate at the higher power levels permitted in the U-NII-3 band (as opposed to U-NII-2A power levels).

²¹ While Globalstar 5 GHz feeder uplinks carry only duplex traffic, the wasted satellite power and resulting reduction in user capacity could also affect Globalstar's provision of one-way, simplex services, including services provided with Globalstar's innovative, consumer-oriented "SPOT" family of MSS devices, because simplex and duplex service rely on the same satellite power supply. Since 2007, SPOT devices have been used to initiate over 2700 rescues, an average of more than one rescue per day.

As described in the Roberson Analysis, feeder uplink interference from outdoor access points would also significantly reduce geographic service availability for Globalstar's two-way MSS customers.²² A reduction in satellite-to-handheld link margin would create geographic gaps in Globalstar's MSS coverage, and Globalstar's customers would suffer increased service outages, dropped calls, and failed call attempts. Overall, assuming the operation of 4.4 million outdoor access points, the Roberson Analysis projects that Globalstar's geographic service availability in North America would be reduced by 5%, with more extensive access point deployments having an even greater effect.²³

If Globalstar responded to the access point uplink interference by taking steps to maintain existing geographic service availability, its MSS network would suffer additional reductions in user capacity in the United States and surrounding areas. As the Roberson Analysis describes, if Globalstar compensated for its reduced link margin by reducing its system's "inherent" intra- and inter-beam interference on its CDMA MSS downlink, this approach would likely reduce its user capacity by an additional 13%, meaning an overall loss of user capacity exceeding 50% in affected areas (assuming 4.4 million outdoor access points).²⁴ The Roberson Analysis states that if Globalstar took a different approach and instead maintained geographic service availability by

²² Roberson Analysis at 24-25.

²³ *Id.*

²⁴ *Id.* at 31. Globalstar would reduce the intra- and inter-beam interference on its CDMA downlink in North America by limiting the amount of usage (and customers) on its MSS network.

increasing its discretionary MSS downlink transmitted power,²⁵ this method would result in a further capacity reduction of 3.5%, meaning an overall capacity loss of approximately 40%.²⁶

While the Commission's proposed rule change would permit unlicensed outdoor U-NII-1 operations only within the United States, the substantial harm to Globalstar's licensed MSS operations would extend well beyond this country's borders. As the Roberson Analysis indicates, given the coverage of Globalstar's satellites and the location of its gateways, this U-NII-1-based interference from the United States would degrade Globalstar's MSS downlink throughout North America, including in Mexico and Canada.²⁷ Similarly, the Roberson Analysis shows that, if the Mexican and Canadian administrations followed suit and permitted outdoor unlicensed operations in this spectrum band, Globalstar's MSS operations within the United States would be degraded.²⁸

Finally, the Roberson Analysis identifies numerous flaws in NCTA's CableLabs Report that invalidate the analysis and conclusions in that study.²⁹ As described in the Roberson Analysis, the CableLabs Report relied on unrealistic "best case" assumptions regarding the

²⁵ As described in the Roberson Analysis at 19-22, Globalstar can increase satellite-to-user CDMA overhead power to overcome interference degradation and maintain existing geographic service availability.

²⁶ Roberson Analysis at 21-22. These capacity effects would increase along with the number of deployed outdoor access points in the U-NII-1 band. If operators collectively deploy ten million or more outdoor access points in the United States, for instance, the Roberson Analysis projects that only a small fraction of user capacity would remain on affected Globalstar satellites. Globalstar's customers would experience this greatly diminished capacity as the equivalent of a blocking or jamming of Globalstar's downlink signal.

²⁷ Roberson Analysis at 2-3, 17.

²⁸ *Id.* at 17.

²⁹ *Id.* at 25-29.

characteristics of outdoor access points,³⁰ and also made critical mathematical and methodological errors in its interference calculations.³¹ As a result of these errors, the CableLabs Report failed to recognize the harmful impact of unlicensed outdoor access point operations on Globalstar user capacity and geographic service availability, and grossly overestimated the number of outdoor U-NII-1 access points that could operate without causing harm to Globalstar's MSS network.³² The CableLabs Report also completely ignored the effects of access point uplink interference on Globalstar's satellite power resources. Accordingly, the CableLabs Report is both inaccurate and incomplete, and the Commission cannot rely on this report to assess the actual impact of its U-NII-1 proposals on Globalstar's licensed MSS operations.

III. THE COMMISSION SHOULD MAINTAIN ITS EXISTING PROHIBITION ON OUTDOOR ACCESS POINT OPERATIONS IN THE U-NII-1 BAND

Globalstar reiterates its support for the Commission's proposed revisions to the operating rules for U-NII-2A and U-NII-3 equipment.³³ Globalstar also supports the Commission's proposal to make available additional spectrum for use by U-NII devices, as long as primary operations such as the Fixed Satellite Service and Intelligent Transportation Systems are

³⁰ *Id.* at 25-26. The Roberson Analysis points out that the CableLabs Report estimates the access point duty cycle at 10%, a figure that is not reasonable for peak-hour operations. The CableLabs Report also assumes a 15 dB decrease in access point antenna gain resulting from a 90 degree elevation angle from access point to satellite. A 6 to 9 dB decrease in access point antenna gain is more likely, given a 30 degree elevation angle to the satellite.

³¹ Roberson Analysis at 26-27.

³² The CableLabs Report concluded that Globalstar's MSS network could tolerate the operation of nearly two billion or more outdoor access points, but once its erroneous assumptions and calculations are corrected, the CableLabs interference model projects that Globalstar's network would tolerate less than a million outdoor U-NII-1 access points, a total well below what would likely be deployed in this band.

³³ *See, e.g.*, Globalstar Comments at 3-4.

protected from interference.³⁴ Recognizing the value of unlicensed operations, Globalstar has shared its 5 GHz feeder uplink spectrum with *indoor* U-NII-1 devices since it began providing MSS in 2000, and, as indicated above, it would accept an increase in the U-NII-1 power limit to the level permitted in the U-NII-2A band.³⁵ As the Roberson Analysis demonstrates, however, permitting outdoor U-NII-1 operations would result in substantial harm to an established MSS licensee and its current customers, including rural consumers and public safety personnel, and threaten future services. Consistent with its rules and policies protecting licensed services from harmful interference from unlicensed operations,³⁶ the Commission should maintain its prohibition on the outdoor operation of unlicensed devices in the U-NII-1 band.

³⁴ See Comments of SES S.A. and Intelsat S.A., ET Docket No. 13-49 (May 28, 2013); Comments of Intelligent Transportation Society of America, ET Docket No. 13-49 (May 28, 2013).

³⁵ See *supra* at 3; Globalstar Comments at 6 n.18.

³⁶ See 47 C.F.R. § 15.5(b); *Terrestrial Use of the 2473-2495 MHz Band for Low-Power Mobile Broadband Networks; Amendments to Rules for the Ancillary Terrestrial Component of Mobile Satellite Service Systems*, Notice of Proposed Rulemaking, IB Docket No. 13-213, FCC 13-147, ¶ 10 (rel. Nov. 1, 2013) (“As a general condition of operation, Part 15 devices may not cause harmful interference to any authorized services and must accept any interference that may be received from them or other Part 15 devices.”); *Amendment of Part 15 of the Commission's Rules to Amend the Definition of Auditory Assistance Device in Support of Simultaneous Language Interpretation*, Report and Order, 28 FCC Rcd 6658, ¶ 3 (2013) (same); *Fostering Innovation and Investment in the Wireless Communications Market; A National Broadband Plan For Our Future*, Notice of Inquiry, 24 FCC Rcd 11322, ¶¶ 21 n.10, 23 (2009) (“Stations of a secondary service shall not cause harmful interference to stations of primary services to which frequencies are already assigned Unlicensed devices generally share the spectrum with allocated radio services on a noninterference basis. That is, unlicensed devices may not cause harmful interference to allocated radio services and must accept any interference they receive.”); *Connected & On the Go: Broadband Goes Wireless, Report by the Wireless Broadband Access Task Force*, GN Docket No. 04-163, at 14 (Feb. 2005), http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-257247A1.pdf (“The principal operating requirement for unlicensed devices is that their operation cannot cause harmful interference to any authorized service and they must accept all interference received from other devices, including other unlicensed devices.”).

The Commission's fundamental commitment to protecting licensed services such as Globalstar's MSS from interference is reflected in Part 15 of its rules. Specifically, Section 15.5(b) requires that unlicensed equipment (i) be operated on a non-interference basis with respect to licensed services, (ii) accept harmful interference from licensed (as well as unlicensed) facilities, and (iii) terminate operations in the event of harmful interference to licensed services.³⁷ Given the primary status of Globalstar's licensed feeder links, NCTA and its allies should bear the burden of demonstrating that unlicensed outdoor U-NII-1 operations would not cause interference to Globalstar's licensed operations. The Roberson Analysis makes clear that it is impossible for these parties to meet this burden.³⁸

Unless the Commission can be certain that outdoor U-NII-1 operations would *not* have a detrimental impact on Globalstar's licensed MSS system, it should not permit such operations. If such interference does occur, it is not clear that the Commission would have a feasible remedy for this harm. Unlike geographically limited interference between two terrestrial facilities, this interference to Globalstar's satellite network would result from the aggregate emissions of millions of unlicensed devices. Once these outdoor access points were operating commercially in the field, it appears that it would be extremely difficult to "put the genie back in the bottle." Proponents of this rule change have not described any effective interference mitigation strategy in this scenario.

³⁷ 47 C.F.R. 15.5(b)-(c).

³⁸ This action would also be contrary to an ITU resolution limiting terrestrial mobile service in this band to indoor use. Resolution 229, Volume 3, Radio Regulations – Resolutions and Recommendations at 189, Radiocommunication Sector – International Telecommunications Union (Geneva 2012), http://www.itu.int/dms_pub/itu-s/oth/02/02/S02020000244503PDFE.pdf.

If the Commission disregards the record evidence and permits outdoor operations in the U-NII-1 band, this decision would threaten the extraordinary public interest benefits of Globalstar's satellite services just as Globalstar's second-generation constellation is restoring full MSS duplex capability. Certainly, in this proceeding, NCTA and other U-NII-1 proponents have failed to acknowledge that Globalstar's global MSS network has crucial public safety uses that cannot be matched by terrestrial wireless systems.³⁹ Globalstar's MSS system provides critical emergency communications connectivity to rural and remote areas, as well as critical back-up capabilities for public safety personnel in populated areas during disasters when terrestrial facilities can be rendered unavailable. Public safety entities involved in relief efforts in the United States and around the world have relied on Globalstar's satellite services after earthquakes, hurricanes, and other disasters.⁴⁰

³⁹ See NCTA Reply Comments. NCTA in its Reply Comments argued that unlicensed operations represent a more efficient use of the U-NII-1 band than Globalstar's feeder uplinks. *Id.* at 13-14. As the Roberson Analysis points out, "[t]he geographic reach and utility of Globalstar's service is fundamentally different from a terrestrial-based service, and this satellite service has end-user value that cannot be measured by a one-dimensional spectrum efficiency metric." Roberson Analysis at 30. NCTA ignores the unique public safety benefits of Globalstar's global MSS network.

⁴⁰ For example, in a May 20, 2013 *ex parte* letter to the Commission, the New York Power Authority indicated that "during and immediately after Hurricane Sandy, our only means of communication into or out of our facilities located on Long Island was via satellite, over Globalstar's network." Letter from Frank A. Miller, New York Power Authority, to Acting Chairwoman Mignon Clyburn, FCC, RM-11685, at 1 (May 20, 2013, filed May 23, 2013). Similarly, on June 24, 2013, Congressman Cedric Richmond of Louisiana indicated to the Commission that "[m]y constituents and I experienced the effects of Hurricane Katrina first hand when satellite-based communications were so integral in performing safety of life services and response. There were over ten thousand Globalstar phones operating in the Gulf Coast region after Hurricane Katrina. We need to ensure that Globalstar has the ability to continue providing these unique services well into the future." Letter from Congressman Cedric L. Richmond, United States House of Representatives, to Chairwoman Mignon Clyburn, FCC, RM-11685, at 1 (June 24, 2013, filed July 1, 2013); *see also* Letter from Senator Mary L. Landrieu, United States Senate, to Acting Chairwoman Mignon Clyburn, FCC RM-11685 (July 23, 2013, filed July 24, 2013) ("Hurricane Katrina and the subsequent Federal levee breaks devastated New Orleans.

Globalstar can reliably provide these critical services to public safety personnel and other customers throughout North America only if the Commission protects its licensed MSS operations from harmful interference. To this end, the Commission should preserve the U-NII-1 band's existing, fair balance between protecting licensed MSS and promoting the development of unlicensed services. Relying on this equitable balance and the stability of its feeder uplink spectrum, Globalstar spent more than \$1 billion to deploy its second-generation MSS constellation and fully restore its duplex capabilities. The Commission should not allow outdoor U-NII-1 transmissions to jeopardize Globalstar's near-term operational integrity, the future growth and development of its MSS business, and the interests of rural consumers, public safety users, and other MSS customers.

IV. CONCLUSION

The Roberson Analysis demonstrates that the operation of outdoor access points in the U-NII-1 band would have a substantial detrimental impact on Globalstar's licensed MSS operations in the Big LEO band. This outcome is directly contrary to the Commission's Part 15 regulatory framework for unlicensed services and its well-established commitment to protecting licensed

Satellite-based communications were vitally important when terrestrial communications networks became overloaded and failed after this disaster. After Katrina, Globalstar had over ten thousand satellite phones operating in the Gulf Coast region.”).

services from interference. The Commission should revise its approach in the U-NII-1 band and maintain its prohibition on outdoor operations in the U-NII-1 band.

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**REDACTED – FOR PUBLIC INSPECTION
REQUEST FOR CONFIDENTIAL TREATMENT
PURSUANT TO 47 C.F.R. §§ 0.457 AND 0.459**

November 29, 2013

VIA ELECTRONIC FILING

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Federal Communications Commission
445 Twelfth Street SW
Washington, D.C. 20554

Re: Revision of Part 15 of the Commission's Rules to Permit Unlicensed
National Information Infrastructure (U-NII) Devices in the 5 GHz Band
ET Docket No. 13-49
Request for Confidential Treatment of Globalstar, Inc.

Dear Ms. Dortch:

Pursuant to Exemption 4 of the Freedom of Information Act ("FOIA") and the rules of the Federal Communications Commission ("FCC" or "Commission"),¹ Globalstar, Inc. ("Globalstar") hereby requests confidential treatment for the information that has been redacted in the technical study by Roberson and Associates, LLC, *Impact of Proposed U-NII-1 Rule Changes on Globalstar Operations*, appended as Attachment A to the Supplemental Comments of Globalstar, Inc. that are filed herewith in the above-referenced matter ("Globalstar Information"). The Globalstar Information relates to Globalstar's provision of Mobile Satellite Services ("MSS") and includes company-specific, highly confidential and/or proprietary commercial information and technical

¹ 5 U.S.C. § 552(b)(4); 47 C.F.R. §§ 0.457(d) and 0.459; *see also* 18 U.S.C. § 1905 (prohibiting disclosure "to any extent not authorized by law" of "information [that] concerns or relates to the trade secrets, processes, operations, style of work, or apparatus, or to the identity, confidential statistical data, amount or source of any income, profits, losses, or expenditures of any person, firm, partnership, corporation, or association").

data that are protected from disclosure by FOIA Exemption 4² and the Commission's rules protecting information that is not routinely available for public inspection and that would customarily be guarded from competitors.³

1. *Identification of the specific information for which confidential treatment is sought.* Globalstar requests that all of the redacted information contained in the Globalstar Information be treated as confidential pursuant to Exemption 4 of FOIA and Sections 0.457(d) and 0.459 of the Commission's rules, which protect confidential commercial and other information not routinely available for public inspection. The Globalstar Information concerns technical data regarding the power supply in Globalstar's satellites. This is company-specific, competitively-sensitive, business confidential and/or proprietary commercial information concerning Globalstar's satellite operations that would not routinely be made available to the public, and has been carefully guarded from competitors. If it were were disclosed, Globalstar's competitors could use it to determine information regarding Globalstar's competitive position, operations, and performance, and could use that information to gain a competitive advantage over Globalstar.

2. *Identification of the Commission proceeding in which the information was submitted or a description of the circumstance giving rise to the submission.* This information is submitted into the record of the rulemaking proceeding proposing revisions to Part 15 of the Commission's Rules to permit unlicensed National Information Infrastructure devices in the 5 GHz Band (ET Docket No. 13-49). Certain of the Commission's proposals would cause a negative impact on Globalstar's licensed MSS operations. The Globalstar Information is voluntarily provided for the Commission's consideration by Globalstar in order to demonstrate that negative impact.

3. *Explanation of the degree to which the information is commercial or financial, or contains a trade secret or is privileged.* The Globalstar Information contains company-specific, competitively-sensitive, confidential and/or proprietary, commercial, technical, and operational information. This information can be used to determine information about Globalstar's MSS operations that is sensitive for competitive and other reasons. This information would not customarily be made available to the public and customarily would be guarded from all others, especially competitors.

² 5 U.S.C. § 552(b)(4).

³ 47 C.F.R. §§ 0.457(d) and 0.459.

4. *Explanation of the degree to which the information concerns a service that is subject to competition.* The confidential information at issue relates to the provision of MSS, which is subject to vigorous competition from other mobile communications providers. If the information is not protected, Globalstar's competitors will be able to use it to their competitive advantage.

5. *Explanation of how disclosure of the information could result in substantial competitive harm.* Since this type of information generally would not be subject to public inspection and would customarily be guarded from competitors, the Commission's rules recognize that release of the information is likely to produce competitive harm. Disclosure could cause substantial competitive harm because Globalstar's competitors could assess aspects of Globalstar's commercial operations, technologies, and business strategies and could use that information to undermine Globalstar's competitive position.

6.-7. *Identification of any measures taken by the submitting party to prevent unauthorized disclosure, and identification of whether the information is available to the public and the extent of any previous disclosure of the information to third parties.* The confidential information in the Globalstar Information is not available to the public, and has not otherwise been disclosed previously to the public. Globalstar routinely treats this information as highly confidential and/or proprietary. Globalstar assiduously guards against disclosure of this information to others.

8. *Justification of the period during which the submitting party asserts that the material should not be available for public disclosure.* Globalstar requests that the Globalstar Information be treated as confidential indefinitely, as it is not possible to determine at this time any date certain by which the information could be disclosed without risk of harm.

9. *Any other information that the party seeking confidential treatment believes may be useful in assessing whether its request for confidentiality should be granted.* The confidential information contained in the Globalstar Information would, if publicly disclosed, enable Globalstar's competitors to gain an unfair competitive advantage. Under applicable Commission and federal court precedent, the information provided by Globalstar on a confidential basis should be shielded from public disclosure. Exemption 4 of FOIA shields information that is (1) commercial or financial in nature; (2) obtained from a person outside government; and (3) privileged or confidential. The technical information in question clearly satisfies this test.

Additionally, where disclosure is likely to impair the government's ability to obtain necessary information in the future, it is appropriate to grant confidential treatment to that information.⁴ Failure to accord confidential treatment to this information is likely to dissuade providers from voluntarily submitting such information in the future, thus depriving the FCC of information necessary to evaluate facts and market conditions relevant to policy issues under its jurisdiction.

If a request for disclosure occurs, please provide sufficient advance notice to the undersigned prior to any such disclosure to allow Globalstar to pursue appropriate remedies to preserve the confidentiality of the information.

If you have any questions or require further information regarding this request, please do not hesitate to contact me.

Sincerely,

/s/ Stephen J. Berman
Stephen J. Berman
Counsel for Globalstar, Inc.

Attachments

⁴ See *National Parks and Conservation Ass'n v. Morton*, 498 F.2d 765, 770 (D.C. Cir. 1974); see also *Critical Mass Energy Project v. NRC*, 975 F.2d 871, 878 (D.C. Cir. 1992) (*en banc*) (recognizing the importance of protecting information that "for whatever reason, 'would customarily not be released to the public by the person from whom it was obtained'" (citation omitted)).



Roberson and Associates, LLC
Technology and Management Consultants

Impact of Proposed U-NII-1 Rule Changes on Globalstar Operations

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Date: November 27, 2013

Impact of Proposed U-NII-1 Rule Changes on Globalstar Operations

Summary

Technical analysis of potential FCC rule changes to the U-NII-1 band reveals that if such rules were adopted, the deployment of numerous outdoor U-NII-1 devices (millions) at U-NII-2A power levels would have a substantial detrimental impact on the capacity of Globalstar's mobile satellite service system, the availability of its satellite power, and geographic service availability for its customers. The detrimental interference on Globalstar's system would occur at the satellite level, not at the ground station level, as the Globalstar satellites "hear" everything transmitting from 5150 to 5250 MHz across a radius of 2900 km of the earth's surface. Given the "bent pipe" (i.e. no decoding in the satellite) nature of the Globalstar system, the negative impact to Globalstar operation would be manifested on the Globalstar satellite-to-handheld downlink, resulting in a) an increase in the geographic outage areas (an increase in the "no service available" indication to the user; and b) an increase in dropped calls. As such, this negative impact will not be limited to the United States, but will also affect the quality and scope of Globalstar's provision of mobile satellite services over the whole of North America.

The large number of outdoor devices expected to operate in the U-NII-1 band is substantiated by (i) a representative deployment of wireless LAN access in certain urbanized areas, described in this report, (ii) existing and planned deployments by cable companies, (iii) the high likelihood of competing, nationwide deployments of outdoor access points by multiple operators focusing on areas where demand is greatest, and (iv) the absence of any limit on the number of outdoor access points that could be deployed in the U-NII-1 band under the Commission's proposed rules. The major contributor to the negative impact is allowing access points to operate outdoors. For these reasons, and the reason that the number and deployment characteristics of the unlicensed wireless access points operating in the band outdoors cannot be adequately controlled, it is not recommended to adopt the outdoor aspect of the proposed U-NII-1 band rule changes. The analysis is consistent with the previous Globalstar submission to the FCC, and provides a validation of the interference limit recommendations established by the ITU-R.

Successful satellite system service delivery is dependent on a balance between the following performance requirements and operational constraints: the amount of RF power that must be transmitted to the user devices, the finite amount of satellite power available, uplink and overall RF signal-to-noise-plus-interference, geographic service availability, and user capacity. The introduction of outdoor unlicensed access points in the U-NII-1 band causes an increase in the level of undesired interference in the Globalstar earth-station-to-satellite feeder uplink. The technical analysis employed here first evaluates the effect that the resulting rise in overall satellite downlink "noise-plus-interference" has on the CDMA capacity of the Globalstar satellite-to-user device downlink, if geographic service availability is held constant. It is demonstrated that if 1.1 million

unlicensed access points operate outdoors in one of the 20 MHz 802.11 channels with U-NII-2A power levels in the U-NII-1 band, then Globalstar user capacity for the downlink satellite channels corresponding to that ground station-to-satellite uplink spectrum is reduced by approximately *one-half*, for a reference unlicensed access point with 100% duty cycle and no urban blocking. The effect of different access point parameters on the capacity degradation is also analyzed, and it is shown that although the capacity degradation is less, a significant capacity degradation persists for access points with 50% duty cycle and taking clutter into account. This analysis confirms that the interference limits recommended by the ITU-R are appropriate to apply to the Globalstar earth station-to-satellite feeder uplink as established in Globalstar's previously submitted technical report.

Further analysis shows that the increase in interference in the feeder uplink due to unlicensed access points also significantly decreases the satellite power available for RF transmission to users due to three factors: the amplification of the additional interference power by the satellite transponder; the increase in downlink signal power to compensate for the degraded interference-plus-noise; and the increase in necessary CDMA overhead power to compensate for the degraded interference-plus-noise. Taking into account all these effects, and assuming no geographic coverage degradation for the satellite users, 1.1 million access points in operation in each of the 4, 20 MHz channels in the U-NII-1 band degrade satellite power capacity by as much as 40%, reducing user capacity proportionately. This 40% degradation is incurred as an alternative to reducing user capacity by greater than 50% directly as described immediately above. If the transmitted power is not increased to compensate for the degraded interference-plus-noise of the CDMA overheads, then the user quality of service as experienced by geographic service availability is reduced by 5%. This degraded (increased) interference-plus-noise causes an increase in failed user call attempts. Concomitant with the user geographic service area degradation is an *unavoidable* 37% user capacity decrease and increased "system busy" indication to users, due to retransmission of the uplink access point interference and the CDMA closed loop power control that automatically increases user power to maintain call quality. This capacity degradation cannot be eliminated by allowing the geographic service area to degrade with a concomitant increase in the "no service available" indications to the users.

The technical analysis employed relies on unlicensed access point characteristics for antenna gain, deployment location, and duty cycle of operation that are based on actual equipment and deployment scenarios used today, coupled with Globalstar operating characteristics filed with the FCC. The effects of urban "clutter" and building shadowing, and different access point duty cycles on the detrimental impact to Globalstar operations are also presented.

The analysis described here uses likely unlicensed access point deployment characteristics, and estimates the effect on Globalstar capacity, satellite power, and end user performance. In contrast, the previously filed NCTA report to the FCC contains several errors and omissions. That analysis: 1) uses unrealistic assumptions for wireless access point antenna gain and operating characteristics that minimize the impact of the proposed rule changes on Globalstar; 2) erroneously calculates the

resulting rise in “interference plus noise” created in the overall satellite-to-handset device downlink caused by the aggregate effect of a population of wireless access points in the uplink; 3) erroneously calculates the effect of U-NII-1 interference generated in the 20 MHz IEEE 802.11 channels on each of the 1.23 MHz CDMA channels in the Globalstar uplink. The NCTA report openly neglects the effect of the access point interference on Globalstar user capacity, geographic service availability, and satellite power available. For these reasons, the NCTA report is unfortunately both inaccurate and incomplete and cannot be relied on to provide a reliable assessment of the actual impact of changes to the U-NII-1 band rules for unlicensed access point operation.

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1. Introduction

1.1 Potential U-NII-1 Rule Changes

This report describes the results of an independent technical analysis conducted by Roberson and Associates, LLC on the impact to Globalstar's mobile satellite services that would be caused by certain rule changes for the U-NII-1 band.¹ As described in the FCC NPRM, potential rule changes include: a) an increase in the power limits for U-NII-1 band operation from 50 mW to 250 mW, with a maximum EIRP of 30 dBm with 6 dBi antenna gain; and 2) elimination of the restriction on outdoor operation.² These changes would adopt U-NII-2A rules for the U-NII-1 band. Alternative rule changes would adopt U-NII-3 rules for the U-NII-1 band as follows: a) increase the power limits to 1 W, with a maximum EIRP of 36 dBm with 6 dBi antenna gain; and b) eliminate the restriction on outdoor operation.³

1.2 Globalstar Overview

Globalstar currently operates a full-duplex "bent-pipe" global mobile satellite service using a constellation of non-geostationary low earth orbit satellites.⁴ The Globalstar system architecture consists of earth station "gateways" which interconnect with terrestrial networks and communicate to the satellites using a 5096-5250 MHz uplink and a 7 GHz downlink. For communications to the mobile user handheld devices, frequency translating repeaters on the satellite convert 5 GHz uplink signals conveying user information on multiple CDMA channels to 2483.5-2500 MHz at the satellite for retransmission to the mobile user devices. Information from the mobile devices is transmitted to the satellites in CDMA channels in the frequency band 1610-1618.725 MHz. The satellite translates the CDMA channels conveying user information from the mobile devices to the 7 GHz band for transmission to the gateway.

2. Globalstar U-NII-1 Band Interference Scenario

2.1 Globalstar Interference Reference

The interference generated by unlicensed access points to the Globalstar gateway-to-satellite uplink is illustrated in Figure 1. Unlicensed wireless access points using terrestrial wireless local

¹ See *Revision of Part 15 of Commission's Rules to Permit Unlicensed National Information Infrastructure (U-NII) Devices in the 5 GHz Band*, ET Docket No. 13-49, Notice of Proposed Rulemaking. (NPRM)

² Id. at ¶39.

³ Id. at ¶40.

⁴ Information provided by Globalstar, Inc., and *The Globalstar System, Applied Microwave and Wireless*, Summer 1995.

area network (LAN) protocols such as the IEEE 802.11ac⁵ are required to operate on a co-channel, non-interference basis in the frequency region 5170-5250 MHz, communicating with wireless LAN client (user) devices. Since the transmitted power of client devices is typically much smaller than that of the access points, the access points are expected to be the primary potential source of interference to Globalstar. The emissions from the access points intended for the wireless LAN client devices are also radiated in the direction of the Globalstar satellites, and degrade the uplink signals sent from the gateway to the satellite by adding their undesired interfering power to the received signal at the satellite, and causing a rise in the uplink noise-plus-interference level. The degraded received signal at the satellite, consisting of the desired Globalstar uplink, plus noise and the unlicensed device interference, is then translated to the 2500 MHz downlink, thereby ultimately degrading the received signal at the Globalstar client device.

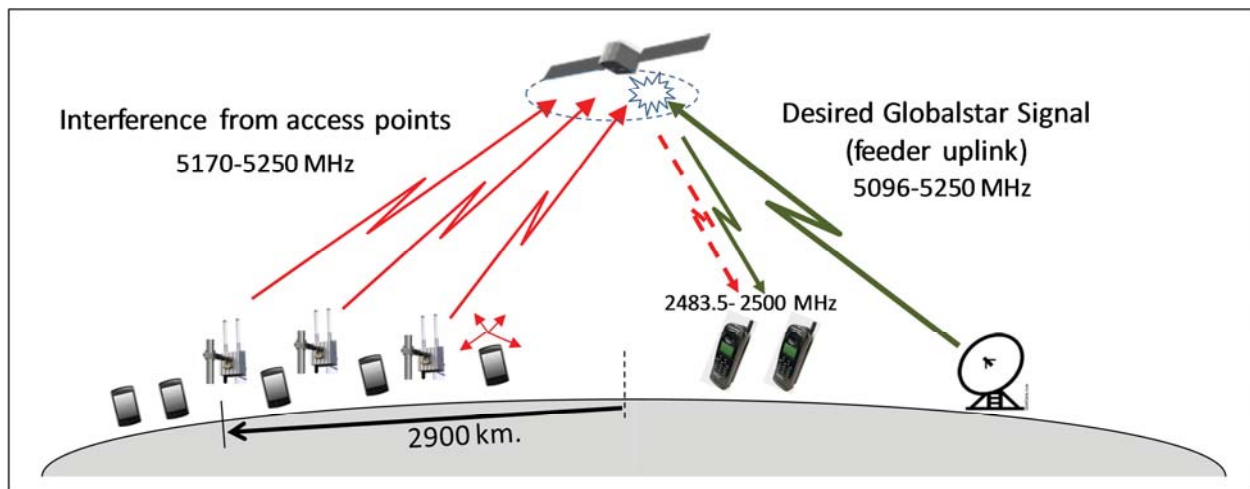


Figure 1: Globalstar Interference Scenario

Unlicensed access points within a satellite “footprint” of approximately 2900 km. radius on the earth’s surface contribute to the interference created in the satellite uplink, as shown in Figure 2. Each approximately circular region in Figure 2 indicates the surface area of the earth serviced by a Globalstar satellite and, thus, the area within which access points would degrade the uplink of one of the Globalstar satellites. The transmissions from all the access points within each of the footprints create an aggregate level of interference at the satellite receiver not limited to the geography of the gateways. This is an aggregate interference problem at the satellite level that manifests itself in the impacted downlink signal to the Globalstar user devices. Referring to Figure 14 which illustrates the Globalstar satellite downlink-to-handheld coverage footprints, it can also be seen that uplink interference created by unlicensed access points operating in the United States would have the same adverse effect on the Globalstar system in both Mexico and Canada. Consequently, Globalstar satellite communications originating and terminating in other countries would be impacted by the proposed rule changes. Additionally, the deployment of outdoor U-NII-1

⁵ See *IEEE TGac Draft Amendment v1.1* [16], August 2011, and *802.11ac Technology Introduction White Paper*, Rohde and Schwartz, http://www.rohde-schwarz.com/en/applications/802.11ac-technology-introduction-application-note_56280-15417.html.

devices at higher power levels in foreign countries would affect Globalstar satellite services provided within the territorial bounds of the United States.



Figure 2. Globalstar Gateway Uplink Satellite Footprints⁶

2.2 Globalstar and U-NII-1 Frequency Plans

Figure 3 illustrates further the interference scenario between unlicensed devices operating in the U-NII-1 band and the Globalstar uplink.⁷ The desired signal, which is a portion of the total Globalstar uplink, consists of 53, 1.23 MHz CDMA channels transmitted in 5 groups of 13, between 5170 and 5250 MHz.

⁶ Provided by Globalstar, Inc.

⁷ Provided by Globalstar, Inc.

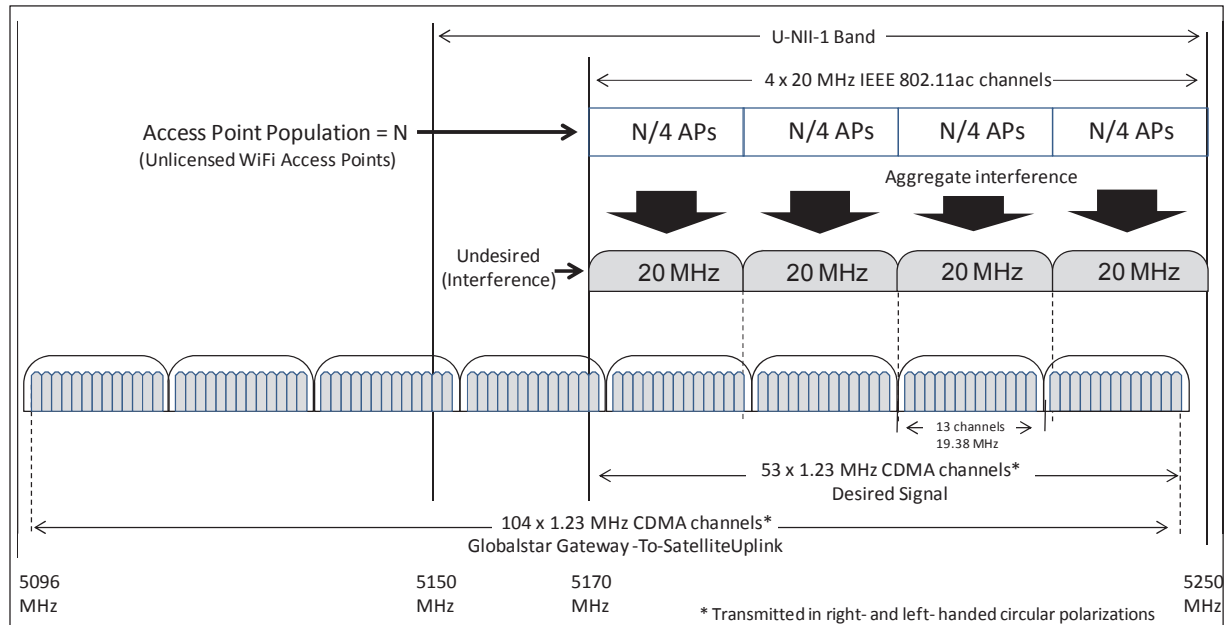


Figure 3: Globalstar Frequency Plan and U-NII-1 Band Interference Scenario

In this representative scenario, a population of N wireless LAN access points utilizing the IEEE 802.11ac standard, each with a 20 MHz bandwidth, is also operating in the U-NII-1 band and within the receiving antenna footprint of the satellite. If the wireless LAN access point population is divided equally among the 4 IEEE 802.11ac channels in the U-NII-1 band, then the emissions from $N/4$ access points generate an aggregate level of interference at the satellite receiver whose power spectral density is the sum of the received powers of $N/4$ access points at the satellite. Since the Globalstar gateway-to-satellite uplink is transmitted in right- and left-hand circular polarizations, a total of 106 CDMA channels are affected by unlicensed access points. Interference in 1 CDMA channel affects two Globalstar beams in 2 separate geographic areas at the same time.⁸

⁸ The IEEE 802.11ac standard provides for access point bandwidths from 20 to 160 MHz. From the standpoint of the analysis of the impact of the unlicensed access points on Globalstar operations, the channel bandwidth of the access points makes no difference. The aggregate interference power spectral density of 4.4 million, 80 MHz bandwidth access points is the same as 1.1 million access points with 20 MHz bandwidth. If 80 MHz access points are deployed, and the total emitted power of each access point is the same as a 20 MHz bandwidth access point, then the power spectral density of each 80 MHz access point is $\frac{1}{4}$ of the power spectral density of a 20 MHz bandwidth access point. But 4.4 million access points in 80 MHz (4 times the number in 20 MHz) are still needed for geographic coverage.

3.0 Impact of Potential U-NII-1 Rule Changes on Globalstar Operations

3.1 Analysis Approach

Introduction

Successful satellite system service delivery is dependent on a balance between the following performance requirements and operational constraints: the amount of RF power that must be transmitted to the user devices, the finite amount of satellite RF transmit power available, the uplink and overall RF signal-to-noise-plus-interference, the geographic service availability, and the user capacity. The introduction of outdoor unlicensed access points in the U-NII-1 band causes an increase in the level of undesired interference in the Globalstar earth-station-to-satellite feeder uplink, affecting the user capacity of the satellite, the satellite RF transmit power available, which also affects the number of users that can be supported, and the geographic service availability. The analyses in this section evaluate the effect of access point interference on all these satellite performance metrics, holding the geographic service availability constant.

The approach to evaluating the impact of a population of unlicensed wireless LAN access points on Globalstar operations is to first determine the likely number of unlicensed access points that would be deployed within the 5170-5250 MHz frequency band that overlaps the Globalstar gateway-to-satellite uplink. This calculation is made in Section 3.2. The determination of appropriate access point characteristics is described in Section 3.3.

The analysis of the effect of unlicensed access point interference on Globalstar capacity, holding geographic service availability constant, is described in Section 3.4. The approach first evaluates the effect that the resulting rise in overall satellite uplink “noise-plus-interference” has on the CDMA capacity of the Globalstar overall satellite-to-user device downlink. Next, typical 802.11 wireless LAN access point deployment characteristics are incorporated into a link budget analysis of the Globalstar gateway to satellite link. The aggregate effect of the emissions from the likely number of unlicensed access points on the Globalstar uplink is calculated as a rise in the noise floor of the gateway to satellite link. The rise in noise floor is compared to the ITU-R recommendations for allowable interference levels to low earth-orbit satellite links. Since the end effect of the interference in the gateway-to-satellite uplink is manifested as a decrease in the signal to noise ratio at the mobile user device receiver, the effect on the satellite downlink is calculated. The end-user effect of the degradation on the Globalstar satellite-to-mobile receiver downlink is then estimated based on an analysis of the CDMA protocol used in that link. This effect is manifested as an increase in overall downlink interference-plus-noise which decreases Globalstar capacity and negatively impacts service availability (coverage) to subscribers. The variation of the negative impact to Globalstar capacity based on the number of access points and their duty cycle and propagation environment (urban clutter and shadowing) is also analyzed.

The analysis of the impact of unlicensed wireless LAN access point interference on Globalstar RF power available for user transmissions is described in Section 3.5. The analysis uses satellite performance characteristics from Globalstar's FCC filings. Additional interference degrades the RF power at the satellite that is available for user communications, also reducing user capacity. The variation of the negative impact to Globalstar RF power available based on the number of access points and their duty cycle and propagation environment (urban clutter and shadowing) is also analyzed.

The impact on Globalstar user quality of service and geographic service availability is described in Section 3.7.

3.2 Expected Number of Unlicensed Access Points

Wireless internet access via use of unlicensed spectrum has increased due to the wide deployment of wireless LAN access points ("hot-spots").⁹ In order to meet user demand, plans have been put in place by the federal government to expand the amount of spectrum and corresponding user capacity available for this capability. Concurrently, commercial entities across the telecommunications industry have developed aggressive plans to deploy networks that provide near-ubiquitous unlicensed wireless LAN internet access in urbanized areas.¹⁰ Wireless internet service providers have also utilized unlicensed spectrum to provide wide-area access in rural areas. The plans of the commercial entities with aggressive access point deployment schedules include outdoor

⁹ See *WiFi Finder*, accessed at <http://v4.jiwire.com/search-hotspot-locations.htm>. As of October 14, 2013, WiFi finder lists 143,000 free and pay WiFi hotspots in the U.S. in its registry, with 826,000 plus worldwide. In June, 2013, Fierce Wireless estimated there would be 6.3 million carrier access points worldwide by the end of 2013, with 50% of traffic from mobile phones, tablets, 3G/4G devices off loaded to WiFi. Tammy Parker, *Report: Worldwide Carrier Wi-Fi Hotspots to Number 6.3M by Year's End*, Fierce Wireless, June 12, 2013, <http://www.fiercewireless.com/tech/story/report-worldwide-carrier-wi-fi-hotspots-number-63m-years-end/2013-06-12>.

¹⁰ For instance, Comcast has stated that it plans to deploy millions of access points nationwide. See *Testimony of Thomas F. Nagel, Senior Vice President, Comcast Corporation, Before the U.S. House Committee on Energy and Commerce, Subcommittee on Communications and Technology, Hearing on "Challenges and Opportunities in the 5 GHz Spectrum Band," November 13, 2013*, at 4, <http://docs.house.gov/meetings/IF/IF16/20131113/101359/HHRG-113-IF16-Wstate-NagelT-20131113-U1.pdf>. Mr. Nagel states that, "[s]o far this year, that number [of access points deployed] has increased to nearly 350,000," and "[w]e are rolling out a new neighborhood hotspot initiative that has the potential to add millions of additional Wi-Fi access points throughout our footprint..." Mr. Nagel adds that "all of our outdoor access points—and all the outdoor access points installed by our cable partners—include the ability to access the 5 GHz band." See also *Comcast to Expand Number of Neighborhood Wi-Fi Hotspots*, USA Today, June 10, 2013, <http://www.usatoday.com/story/tech/2013/06/10/comcast-wifi-hotspots/2407219/> (stating that the Comcast neighborhood deployment, called XfinityWiFi, is part of 150,000-plus hotspot network operated by the CableWiFi Alliance).

deployment.¹¹ Outdoor deployment of unlicensed access points is intended to augment, and in some instances replace, wide-area “4G cellular” service.¹²

Representative of deployment of wireless LAN access in an urbanized area is the network of access points constructed in Mountain View, CA.¹³ In this network, 500 wireless access points are deployed in an area of 31 square kilometers, for an access point density of ~16 access points /square km.¹⁴ Using this as representative of the density of access point deployment that could ultimately be created by just a single commercial entity in the U-NII-1 band, the likely number of wireless access points in the urbanized areas of the United States can be estimated. Table 4 in Appendix A reproduces U.S. census data summarizing the urbanized areas in the U.S., along with their geographic areas. Using the geographic area data, the ultimate number of access points that could exist is readily calculated using the Mountain View deployment density. For the total urbanized area in the U.S., the number of access points would be approximately 4.4 million. For the top urban areas alone, the number of unlicensed access points would be 1.7 million. In the representative link budget example that follows, 4.4 million access points operating in the U-NII-1 band is taken as the number of outdoor access points that could ultimately be expected to operate in that spectral region.

This estimate of outdoor access points in the U-NII-1 band is in fact extremely conservative. There will be multiple operators of unlicensed access point networks nationwide with overlapping coverage in areas where demand is greatest. Given the robust competition between such operators and the absence of any limit on the number of outdoor access points that could be deployed in the U-NII-1 band, it is likely that more than 4.4 million outdoor access points will be deployed in this spectrum band.

¹¹ For example, the website for Comcast’s XFINITY Wi-Fi Hotspots (www.comcast.com/wifi) claims “over 500,000 hotspots”. Examination of the hotspot locations in New York and Los Angeles reveals that most hotspot locations in these cities are located outdoors. (See <http://hotspots.wifi.comcast.com/>.)

¹² Juniper networks states: “Specifications such as Next-Generation Hotspot (NGH) and Hotspot 2.0 along with 5 GHz enable devices will help accelerate carrier Wi-Fi adoption.” Tammy Parker, *Thanks to Wi-Fi, Only 40% of Mobile Data Will Go Over Cellular by 2017*, Fierce Wireless, April 10, 2013, <http://www.fiercewireless.com/tech/story/thanks-wi-fi-only-40-mobile-data-will-go-over-cellular-2017/2013-04-10>.

¹³ See *Google WiFi*, accessed at http://en.wikipedia.org/wiki/Google_WiFi. 500 routers in Mountain View, CA have been deployed in an area of 31 sq km., or 16 routers per sq km; see also *The Future of Google WiFi*, accessed at https://support.google.com/wifi/answer/47607?hl=en&ref_topic=2603788, and *How Google WiFi Works*, https://support.google.com/wifi/answer/30814?hl=en&ref_topic=2603788.

¹⁴ Similarly, Time Warner Cable has deployed a network of “thousands” of access points in a 40 square mile area of Southern California. Assuming that “thousands” includes 2000 outdoor access points, then the outdoor access point density is about 20 access points/square km, approximately the same as the Google deployment described above. See *Comments of Time Warner*, ET Docket No. 13-49, at 5 (May 28, 2013).

3.3 Unlicensed Access Point Characteristics

Location and Antenna Gain

A common practice is to locate unlicensed outdoor access points on utility poles, with omnidirectional antennas at a height of 5-8 meters, and with 6 dB gain. (See Figure 10 in Appendix B). Considering the Globalstar satellite constellation, a representative transmission path to the satellite from a population of outdoor, unlicensed wireless LAN access points will be at a 30 degree elevation angle. This implies approximately a 6 dB gain reduction of the access point antenna in the direction of the satellite. The impact of unlicensed access point interference for antenna gain reduction factors of 6 dB and 9dB, due to elevation angle to the satellite, will be evaluated.

Radiowave Propagation

Free-space radiowave propagation from the access points to the satellite, with a spread factor based on the distance to the satellite at a 30 degree elevation angle, is the basis used to compute the interfering signal strength received at the satellites. With relatively low elevation angles (30 to 60 degrees) from the unlicensed access points to the satellite, additional RF propagation impairments beyond free-space attenuation will be experienced. With an antenna height significantly above the height of a mobile or handheld antenna (about 1 meter for a vehicle), the additional attenuation over free-space due to clutter and shadowing will be less severe than indicated by the numerous studies of satellite-to-mobile scenarios.¹⁵ Based on these studies, two methods for taking clutter/shadowing into account are appropriate. The first method employs an additional fixed attenuation factor of 3 dB applied to all access points. This clutter factor, less severe than the 6-10 dB attenuation values previously reported for satellite-to-mobile (street level) communication paths, is justified due to the increased access point antenna height compared to paths to vehicles at street level.¹⁶ The second method, also based on the satellite-to-vehicle propagation measurements,¹⁷ models building shadowing in urban areas by assigning a "blocking factor" to the access point population, and calculating the impact of unlicensed access points on Globalstar operations for different blocking factors. For example, a 10% blocking factor indicates that emissions from 10% of the total number of access points are completely shadowed (blocked) to the satellite. Impact of unlicensed access points on Globalstar operations will be evaluated for blocking factors of 10% and 20%, more severe than the approximate 3% shadowing level measured in an actual urban environment.¹⁸

¹⁵ See ITU, *Handbook, Radiowave Propagation Information for Predictions for Earth-to-Space Path Communications*, <http://www.itu.int/pub/R-HDB-27>, D.O. Reudink, *Estimates of Path Loss and Radiated Power for UHF Mobile-Satellite Systems*, Bell Systems Technical Journal, Vol. 62, No. 8, Oct. 1983, and Julius Goldhirsh and Wolfhard J. Vogel, *Propagation Effects for Land Mobile Satellite Systems: Overview of Experimental and Modeling Results*, NASA Reference Publication 1274, February 1992.

¹⁶ Id.

¹⁷ See Yoshikawa, M.; Kagohara, M., "Propagation characteristics in land mobile satellite systems," Vehicular Technology Conference, 1989, IEEE 39th, vol., no., pp.550,556 vol.2, 1-3 May 1989.

¹⁸ Id.

Duty Cycle

During busy periods, greater than 80% duty cycles can be observed for access points, since most traffic is in the access point-to-handheld device direction (access point downlink). Observations of access point traffic in heavy traffic areas validate this. (See Appendix B). Studies of access point throughput indicate that maximum (download) throughput is reached at a duty cycle of 80%.¹⁹ In addition, many unlicensed access point network systems employ a “mesh” architecture in which access points relay information to each other, creating additional high-duty cycle access point activity.²⁰ In a mesh network, the user traffic on the wireless LAN spectrum is repeated and relayed from access point to access point to provide backhaul to a wired interconnect point. The repeated user traffic multiplies the transmissions of the access points, increasing their duty cycle.

Unlicensed access point interference affecting Globalstar operations will vary on a daily basis with human activity and access point loading, with maximum interference peaking during the “busy hours.” For this reason, the interference impact will be evaluated for access point duty cycles of 50%, 80% and 100%. While not expected during the peak traffic periods, a duty cycle of 50% provides a lower limit on the level of interference that will be expected from a population of outdoor access points, and provides a lower bound on the effect that unlicensed access points will have on Globalstar operations. The appropriate method of calculating the impact of interference due to unlicensed access points is to consider the time of day when activity is highest, since those are the times when Globalstar operations will be impacted the greatest. It is not appropriate to use an access point utilization averaged over a 24 hour time period, for example.

3.4 Link Budget and Interference to Globalstar’s Licensed Operations

A representative link budget which incorporates the likely access point numbers and deployment parameters is presented below in Table 1. The format follows that used by Globalstar in a previous submission to the FCC, but incorporates the interference scenario parameters as described above, and access point characteristics aligned with U-NII-2A rules. The link budget shows the impact of rule changes for outdoor operation aligned with both the U-NII-2A and U-NII-3 frequency bands.

Explanation of Link Budget

The ITU-R has established recommended limits for the interference power flux density on the uplink of communications satellites such as Globalstar.²¹ Row Q in the link budget indicates the

¹⁹ Nickolas J. LaSorte, Dan Bloom, et al., “Comparison of Duty Cycle Measurement Techniques of 802.11b/g in the Frequency and Time Domain,” *Instrumentation and Measurement Technology Conference (I2MTC), 2013 IEEE International*, 6-9 May 2013, Minneapolis, MN.

²⁰ See Whitepaper, Next Generation Wireless Mesh Networks, Aruba Networks, March 2011, accessed at http://www.arubanetworks.com/pdf/technology/whitepapers/WP_WirelessMesh.pdf

²¹ ITU-R recommendations S.1426, *Aggregate Power Flux Density Limits, at the FSS Satellite Orbit for Radio Local Area Network Transmitters Operating in the 5150-5250 MHz Band Sharing Frequencies*, and S.1432,

aggregate interference level generated by the number of unlicensed access points that are expected to operate in a single 20 MHz IEEE 802.11ac channel. For U-NII-2A rules, this level is approximately 27 dB higher than the maximum level of interference indicated in ITU-R recommendation S.1426. For U-NII-3 rules, this level is 33 dB higher than the ITU-R recommendation. The analysis provided here follows the framework used by Globalstar, Inc. in its May 2013 Comments to the FCC regarding the NPRM.²²

Row V in Table 1 indicates the rise in the noise floor in the Globalstar gateway-to-satellite uplink caused by the aggregate effect of unlicensed wireless access points. This value can be used to calculate the degradation in carrier-to-noise ratio experienced on the satellite-to-mobile user device link, through the following relationship for satellites that act as repeaters.²³

$$\left(\frac{C}{N}\right)_{ovr} = \left[\left(\frac{C}{I_{up} + N_{up}}\right)^{-1} + \left(\frac{C}{N_{down}}\right)^{-1} \right]^{-1}$$

In this equation, N_{up} and N_{down} are the noise powers in the satellite uplink and downlink, respectively, and I_{up} is the level of interference in the satellite uplink generated by the unlicensed access points, and $(C/N)_{ovr}$ is the overall carrier-to-noise ratio experienced at the mobile satellite receiver user device. Row W indicates that the resulting 10 dB noise rise in the gateway-to-satellite uplink for access points operating under U-NII-2A rules, and the 15.7 dB noise rise for access points using U-NII-3 rules, respectively, create a 0.5 dB degradation and 1.7 dB degradation in overall satellite downlink $(C/N)_{ovr}$ experienced at the mobile satellite receiver.

The significant impact of unlicensed access point interference on the Globalstar uplink and overall downlink carrier-to-noise plus interference is caused primarily by the outdoor operation of the large number of access points planned to be deployed. Indoor operation adds an additional 18 dB of attenuation to the emissions from the access points, significantly reducing their impact. The degradation of the satellite-to-handheld user device CDMA downlink capacity, degradation of satellite RF power, and user quality of service due to the unlicensed access point interference is discussed in Sections 3.5-3.7.

Appointment of allowable error performance degradations to fixed-satellite service (FSS) hypothetical reference digital paths arising from time invariant interference for systems operating below 30 GHz.

²² See *Comments of Globalstar, Inc., In the Matter of Revision of Part 15 of the Commission Rules to Permit Unlicensed National Information Infrastructure (U-NII) Devices in the 5 GHz Band*, ET Docket No. 13-49, May 28, 2013. (Comments of Globalstar)

²³ See *Satellite Communication Systems*, p. 117, M. Richharia, McGraw Hill, Second Edition, 1999.

Table 1: Impact to Globalstar (C/N) Overall: Link Budget Calculation

Ref.	Parameter	U-NII-2A Rules	U-NII-3 Rules	
A	Satellite altitude	1414	1414	km
B	Spread loss (30 degree elevation angle: sat. distance = 2320 km)	-138	-138	dB
C	Area of 0dB gain antenna at satellite	-35.4	-35.4	dB sq m
D	(equivalent path loss)	-173.4	-173.4	dB
E				
F	UNII-2 Max EIRP (w. 6 dBi antenna)	30	36	dBm
G	UNII-2 EIRP density (dBW/MHz) 20 MHz	-13.0	-7.0	dBW/MHz
H	Building attenuation	0	0	
I	AP antenna gain (loss) relative to 6 dB (30 degree elev. angle)	-6	-6	dB
J	Power Flux Density of Single UNII access point	-157.0	-151.0	(dBW/MHz/ sq m)
K	Power Density of Single UNII access point	-192.4	-186.4	(dBW/MHz)
L				
M	Expected devices in UNII-1 band (4 chls x 20 MHz)	4,400,000	4,400,000	Access points
N	Expected AP s(devices) in 20 MHz UNII chl (100% duty)	1,100,000	1,100,000	Access points
O	Expected (dB devices) in 20 MHz UNII chl	60.4	60.4	(dB) Access points
P				
Q	Aggregate Interference of Expected Devices in 20 MHz channel	-96.6	-90.6	dBW/MHz/sq m
S	ITU Interference recommendation (ITU-R 1426)	-124	-124	dBW/MHz/sq m)
T				
U	Additional interference over ITU rec.	27.4	33.4	dB
V	(I+N)/N (noise floor increase in uplink)	10.0	15.7	dB
W	Overall C/N decrease at handheld receiver	0.5	1.7	dB
X				
Y	Received int. level for ITU rec. S.1426	-159.4	-159.4	dBW/MHz
Z	Received int. level for ITU rec. S.1432	-161.5	-161.5	dBW/MHz
AA				
AB	Globalstar T	509.3	509.3	(deg. K)
AC	log (T)	27.1	27.1	dB deg.K
AD	Boltzmann's Constant (k)	-228.6	-228.6	dBW/K/Hz
AE	Noise floor kTB	-141.5	-141.5	(dBW/MHz)
AF	1.5% deltaT/T of ITU S.1426 (interference/noise)dB	17.9	17.9	dB
AG	1 % deltaT/T of ITU S.1432	20	20	dB

3.5 Impact on Globalstar Capacity

3.5.1 Approach

The following approach is used to estimate the effect of unlicensed wireless LAN access points on the overall Globalstar CDMA downlink capacity (satellite-to-handheld device), assuming that the geographic service area is held constant.

1. Calculate the Interference Generated in the Uplink by Wireless LAN Access Points.

Unlicensed access points create interference in the Globalstar earth station-to-satellite uplink. This uplink is carrying CDMA channel downlink information that is received at the satellite, amplified and retransmitted to the Globalstar handheld user devices. The interference degrades the $E_b/(N_o + I_o)_{up}$ of the Globalstar uplink via an additional interference term I_a in the relationship: $E_b/(N_o + I_o + I_a)_{up}$. The additional interference I_a is calculated as the sum of the received powers of the total number of unlicensed access points at the satellite receiver.

2. Calculate the Rise in Interference on the Overall Globalstar Downlink.

The additional interference term in the Globalstar uplink degrades the $E_b/(N_o + I_o)_{ovr}$ of the downlink as experienced at the Globalstar handheld receiver. The degraded $E_b/(N_o + I_o + I_a)_{ovr,deg}$ is calculated using the relationship²⁴:

$$\frac{E_b}{N_o + I_o + I_a}_{ovr,deg} = \left[\left(\frac{E_b}{N_o + I_o + I_a} \right)_{up}^{-1} + \left(\frac{E_b}{N_o + I_o} \right)_{dn}^{-1} \right]^{-1}$$

3. Calculate the Decrease in Inherent Interference in the Globalstar CDMA Downlink Required to Compensate for the Overall Interference Rise Caused by the Access Points in the Uplink

The CDMA channels on the overall satellite-to-handheld downlink require a minimum overall $E_b/(N_o + I_o)_{MIN,ovr}$, prior to any additional coherent combining receiver gain, to maintain acceptable bit error rate and user performance after combining is taken into effect. In this equation, I_o is the inherent interference spectral density resulting from the sum of intra-beam and adjacent-beam co-channel Globalstar CDMA users. Since the $E_b/(N_o + I_o)_{ovr}$ value has been degraded due to the addition of additional unlicensed access point interference, resulting in $E_b/(N_o + I_o + I_a)_{ovr}$, $I_{o,dn}$ must be reduced to $I_{o,dn,red}$ to

²⁴ Id.

maintain the value $E_b/(N_o+I_o)_{MIN,ovr}$ required for acceptable communications performance. That is,

$$\frac{E_b}{N_o + I_o}_{MIN, ovr} = \left[\left(\frac{E_b}{N_o + I_o + I_a}_{up} \right)^{-1} + \left(\frac{E_b}{N_o + I_{o,red}}_{dn} \right)^{-1} \right]^{-1}$$

where $E_b/(N_o+I_o)_{MIN,ovr}$ is taken before any coherent combining. The individual values for N_o , I_o , and I_a are known for the uplink and downlink, along with the value

$E_b/(N_o+I_o)_{MIN,ovr}$. Therefore $I_{o,red,dn}$ can be calculated for values of I_a --corresponding to uplink interference from the access points-- as follows:

$$\left(\frac{E_b}{N_o + I_{o,red}}_{dn} \right) = Incr \times \left(\frac{E_b}{N_o + I_o}_{dn} \right)$$

or,

$$I_{o,red} = \frac{1}{Incr} I_o + \left(\frac{1}{Incr} - 1 \right) N_o$$

where $Incr$ = the fraction increase in downlink $E_b/(N_o+I_o)_{dn}$ needed to compensate for the degraded uplink and maintain the overall $E_b/(N_o+I_o)_{MIN,ovr}$, before any coherent combining.

4. Calculate the Globalstar Downlink Capacity Decrease Due to Required Decrease in Inherent CDMA Interference.

Since I_o and $I_{o,red}$ represent the sum of the co-channel Globalstar user powers on the CDMA downlink, the reduction in interference power is directly proportional to the reduction in CDMA subscriber capacity. This is a result of the fact that CDMA capacity on the downlink is related to the interference generated by co-channel downlink users.

The inherent CDMA downlink interference sources are described further in Appendix C.

3.5.2 Link Budget and Capacity Impact Calculation

The link budget in Table 2 below illustrates the calculation of the reduction in CDMA downlink capacity using link budget parameters from Globalstar's FCC filing²⁵, and the value of I_a (access point interference) caused by 1.1 M access points in a 20 MHz IEEE 802.11ac channel, a likely value

²⁵ See *Application for Modification of Nongeostationary Mobile Satellite Service System License (S2115) to Launch a Second Generation System*, IBFS File Nos. SAT-MOD-20080904-00165, SAT-AMD-20091221-00147 (Globalstar Filing).

for the number of unlicensed access points that can be expected to operate outdoors in the U-NII-1 band, using U-NII-2A rules as proposed by the NPRM. In this calculation, the geographic service area is maintained at the same level as that without outdoor unlicensed access point interference.

Since the downlink CDMA protocol used in Globalstar's MSS network is based on the terrestrial CDMA standard, an analysis based on the approach used to estimate terrestrial CDMA capacity can be utilized to determine capacity degradation in the mobile satellite CDMA downlink.²⁶ The overall $E_b/(N_o + I_o + I_a)_{ovr}$ degradation at the mobile satellite receiver due to unlicensed access point interference in the Globalstar uplink gateway, determined in the representative link budget calculation in Section 3.4, Table 1, is used to estimate the capacity degradation.

²⁶ *Introduction to Spread Spectrum Communications*, R. Peterson, R. Ziemer, and D. Borth, Prentice Hall, 1995.

Table 2: Link Budget for Calculation of Downlink Capacity Reduction

Ref.	Parameter			Note
	Forward Link Budget			
A	Uplink Eb/(Io+No)	19.9	dB	Globalstar filing
B				
C				
D	Rx signal/user/satellite	-168	dBW/1.23 MHz	Globalstar filing
E	Log Bandwidth	60.90		
F	Rx signal density	-228.90	dBW/Hz	
G				
H	Downlink No	-203.9	dBW/Hz	Globalstar filing
I	Avg data rate (2400 bps)	33.80	dB bit/sec	Globalstar filing
J	Eb/No = (D -I- H)	2.10		
K				
L	Downlink Interference Io per chl	-148.7	dBW	Globalstar filing
M	Downlink Io density	-209.60	dBW/Hz	
N	Downlink No + Io	-202.9	dBW/Hz	
O	Down link Eb/(No+Io)	1.06	dB	Globalstar filing
P	Overall Eb/(No+Io) [= Overall Eb/(No+Io)MIN]	1.01		Globalstar filing; Overall Eb/No equation
Q	Coh combining gain	2.5	dB	Globalstar filing
R				
S	Resulting Overall Eb/(Io+No) [= P+Q (after coh comb)]	3.5		Globalstar filing
T	Overall Eb/(Io+No)MIN needed, after coh comb	3.5		Globalstar filing
U				
V	Degradation in Uplink Eb/(No+Io)	10	dB	from access point calculation. Table 1, row V
W	Uplink Eb/(No+Io+Ia) [= A-V]	9.9	dB	
X	Overall Eb/(No+Io+Ia) (Degraded)	0.53	dB	Equation for overall Eb/No
Y	Degradation in Overall Eb/(Io+No) [= P-X]	0.48	dB	
Z				
AA	Increase (Incr) in Downlink Eb/(No+Io) to maintain 1.01 overall, since uplink is degraded.	0.55	dB	Equation for overall Eb/No
AB	Increase (Incr) in Downlink Eb/(No+Io) to maintain 1.01 overall, since uplink is degraded.	1.134	linear	
AC				
AD				
AE	New reduced downlink Io required = Io, red, to maintain 1.01 overall	-213.1		dBW/Hz, Equation for Io,red
AF	Reduction in downlink Io required to maintain Eb/(Io+No)MIN [= M-AE]	3.55	dB	for 1.1 M access points, U-NII-2 rules, outdoor
AG	Relative Capacity	0.44		Linear
AH	Capacity Reduction	56%		

It is seen that 1.1 million access points operating outdoors under U-NII-2A rules, in a 20 MHz 802.11ac channel bandwidth as described in Section 3, will cause greater than a 50% reduction in Globalstar downlink capacity in those CDMA channels being conveyed on the Globalstar earth station-to-satellite link within that 20 MHz bandwidth. 4.4 million access points, evenly distributed across the 4 IEEE 802.11ac channels in the 80 MHz U-NII-1 band, affect more than half of the Globalstar CDMA user channels. (53 of 104 as shown in Figure 3.)²⁷

²⁷ The increase in downlink Eb/(No+Io) needed to maintain necessary user quality in row AA in Table 2 (0.55dB), differs slightly from the corresponding value in row W, Table 1 (0.5dB). More accurate satellite parameters from the *Globalstar Filing* have been used in Table 2.

3.5.3 Capacity Impact as a Function of Active Wireless LAN Access Points

Using the approach for calculating the degradation in overall $E_b/(N_o+I_o)$ described in Table 2 for a specific number of unlicensed access points, the degradation as a function of the number of access points can readily be calculated, holding geographic service availability constant.

First, the Uplink and Overall $E_b/(N_o+I_o)$ degradation as a function of the number of unlicensed access points is calculated. The result is shown in Figure 4, which plots the degradation in overall downlink (CDMA) $E_b/(N_o+I_o)$ ratio, as a function of the number of unlicensed access points operating in a single 20 MHz channel of the U-NII-1 band under U-NII-2A rules, for a satellite elevation angle of 30 degrees. In alignment with Table 1, it can be seen that 1.1 million access points cause a 0.55 dB degradation in the overall CDMA $E_b/(N_o+I_o)$ (see dashed line).

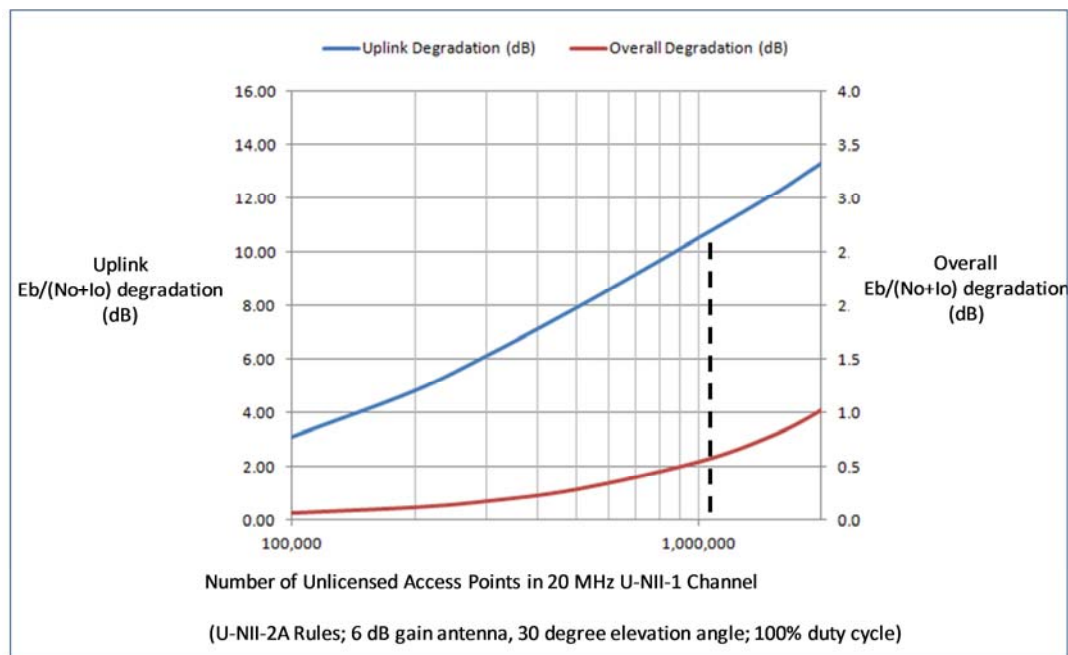


Figure 4. Uplink and Overall Degradation vs. Number of Unlicensed Access Points

Then, using the relationship plotted in Figure 4, the impact of the number of unlicensed access points on Globalstar CDMA capacity can be assessed.

Curve (a) in Figure 5 illustrates the result of the relative capacity calculation of the overall Globalstar CDMA downlink as a function of the number of active wireless LAN access points operating outdoors in the U-NII-1 band, using U-NII-2A band power limits. The path loss for a 30 degree elevation angle from access point to satellite is used, along with a 100% access point duty cycle, and 6 dB antenna gain loss due to elevation angle is plotted. Table 7 in Appendix C provides the detailed calculations used to arrive at the Figure 5(a) result, following the approach in Section 3.5.1, and the calculation method in Table 2.

If 1.1 million access points are operational within a 20 MHz IEEE 802.11ac channel bandwidth, a likely scenario given the stated plans of commercial entities planning to deploy networks in this band, then the Globalstar capacity for the 53 CDMA channels conveyed in that spectrum will be reduced by 56%. This is consistent with the capacity degradation as calculated in Table 2. Given the aggressive plans for unlicensed access point deployment described previously, the potential for even greater impairment of Globalstar's CDMA satellite-to-handset downlink capacity exists, equivalent to completely blocking or jamming the downlink. As indicated in Figure 2 and Figure 14, impairment can occur for Globalstar service areas outside the U.S. in Canada and Mexico due to access points located within the U.S. Similarly, the deployment of outdoor UNII-1 devices at higher power levels in Mexico and Canada would impair the provision of Globalstar satellite services within the United States.

Variation in Capacity Impact Due to Access Point Parameters

The capacity loss for a reference access point with 100% duty cycle with a 30 degree elevation angle to the satellite, and 9 dB antenna gain loss is shown in curve (b) in Figure 5. It is seen that even though the access point antenna gain has a higher loss of 9 dB, only 400,000 access points operating at a 100% duty cycle in a 20 MHz IEEE 802.11ac channel will create a capacity degradation of 10% for the CDMA channels in that 20 MHz bandwidth. For access points with an antenna gain loss of 6 dB and a 30 degree elevation angle, only 200,000 access points will create the same 10% capacity degradation. If 800,000 access points are distributed evenly across the 53 CDMA Globalstar channels on the earth-station-to-satellite feeder link as shown in Figure 3, then the capacity of the Globalstar downlink for user communications for all those channels will be reduced by 10%.

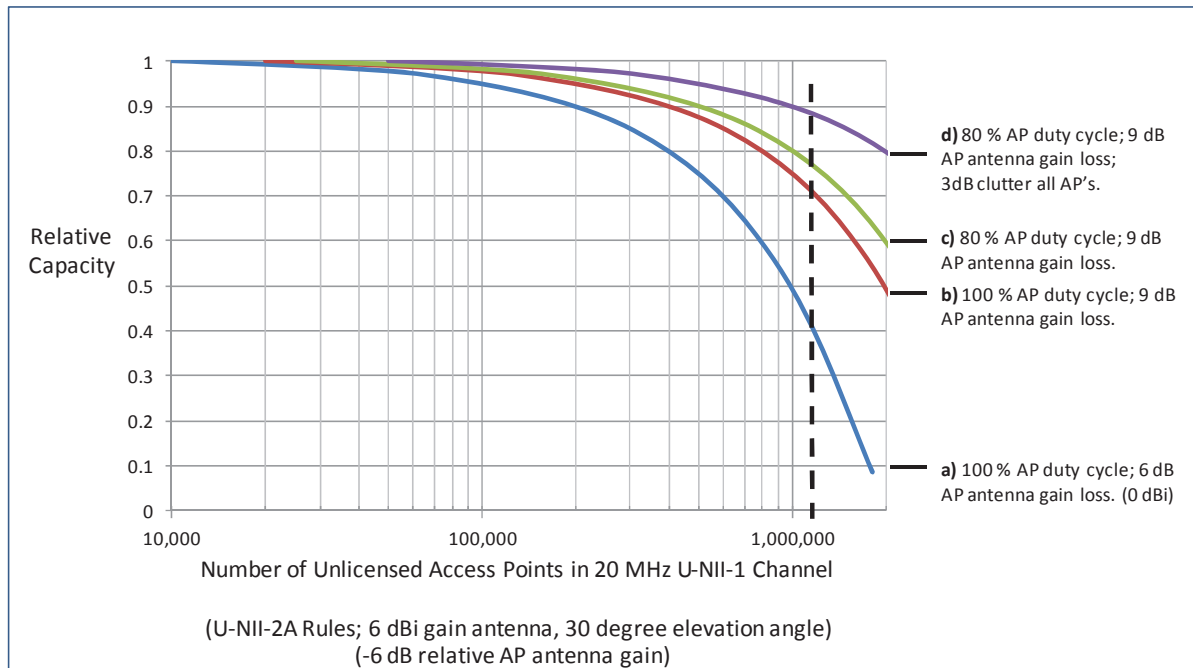


Figure 5. Relative Globalstar Downlink Capacity as a Function of Number of Access Points and AP Parameters.

Curves (c) and (d) show the capacity loss to the Globalstar downlink channels for 80% access point duty cycle and 9 dB antenna gain loss, and 80% access point duty cycle, 9 dB antenna gain loss, and 3 dB clutter attenuation factor applied to all access points, respectively. Even for these access point operational characteristics, which represent “best case” or “least interference” scenarios, there is a 22% and 10% capacity degradation for the 1.1 million unlicensed access points expected to operate in each of the 4, 20MHz IEEE 802.11ac channels in the U-NII-1 band.

3.6 Impact on Satellite Power Available

In the previous section, a decrease in 0.55 dB in the overall signal-to-noise plus interference was shown to cause a significant capacity decrease of 56% if user transmit power and geographic availability were held constant, depending on the access point operational characteristics. The introduction of additional interference due to the presence of outdoor unlicensed access points in the Globalstar earth station-to-satellite uplink, however, also has a significant impact on the finite amount of available satellite RF power. In this section the impact of access point interference on available satellite power due to the following factors is analyzed: 1) additional power consumed by amplification and retransmission of the additional uplink interference; 2) increase in power in CDMA overhead channels to maintain the signal-to-noise-plus-interference necessary for successful communications; 3) transmitted power increase to maintain the overall signal-to-noise-plus-interference ratio of the user communications channels at the handheld device to maintain geographic service availability. The additional power consumed by amplification of the unlicensed access point interference cannot be avoided. Since the CDMA downlink user channels employ

closed loop power control, the user transmit power is increased to maintain the user call quality. This additional RF power consumed is also unavoidable. If the satellite-to-user CDMA overhead power is increased to overcome the signal-to-noise-plus-interference degradation and maintain the geographic service availability, the satellite power is further reduced and degraded. This reduction in satellite RF power steals power from user communications and in turn reduces the number of users that can be supported. A small portion of the capacity reductions described here are alternative effects to the capacity degradation discussed above in Section 3.5. However, the additional power consumed by amplification of the unlicensed access point interference and automatic increase in user power is always incurred, and represents a base, inherent level of capacity reduction incurred in the direct calculation of capacity impact in Section 3.5.

Table 3 below illustrates the method of calculating the impact of access point interference on available satellite power. The method is summarized as follows:

1. Rows A through D use the calculation of received interference power due to unlicensed access points from Table 1 to provide the starting point for the aggregate interference power that is amplified by the satellite transponder. For this calculation, the access points are assumed to operate outdoors using U-NII-2A service rules. Using satellite parameters provided in Globalstar's FCC filing,²⁸ row H is the resultant uplink received interference power that is amplified by the nominal transponder gain of 122.7 dB.
2. Applying the transponder gain of 122.7 dB, the resulting amplified downlink interference power spectral density resulting from 4.4 million access points equally distributed over the 80 MHz of the U-NII-1 band is calculated as **[begin confidential]** [REDACTED] **[end confidential]** (row M). This is the additional satellite power consumed (wasted) by amplification of the access point interference.
3. Rows O through AB use Globalstar satellite characteristics from the FCC filing²⁹ to calculate the **[begin confidential]** [REDACTED] **[end confidential]** of additional overhead power consumed (wasted) by increasing the CDMA overhead transmitted power to compensate for the degraded signal-to-noise-plus-interference caused by the unlicensed access points. In the Globalstar satellites, 15% of the CDMA downlink power is consumed by pilot, synchronization, and paging channels.³⁰
4. The total power wasted merely due to amplifying the interference is **[begin confidential]** [REDACTED] **[end confidential]** (row W), or 28.7% of the nominal Globalstar satellite transmit power available. **[begin confidential]** [REDACTED] **[end confidential]**

²⁸ See *Globalstar Filing*.

²⁹ See *Globalstar Filing*.

³⁰ See *CDMA2000 Evolution*, Kamran Etemad, John Wiley and Sons, 2004, p. 57. In a CDMA downlink, the total transmitted power is divided among overhead channels and user traffic channels. The overhead channels consisting of pilot, sync, and paging channels take a static allocation of transmitted power which does not change with the number of users. In a terrestrial IS-95 CDMA network, the overhead consumes 25-30% of maximum available power. In the Globalstar system, the overhead is 15% of the available transmit power.

5. Row Y calculates the additional 0.55 dB transmitted power required to compensate for the degraded overall signal-to-noise plus interference caused by 4.4 million access points. This is [begin confidential] [REDACTED] [end confidential] or 12% of the transmit power available.

The overall lost power due to amplifying the interference and increasing the transmit power to compensate for degraded downlink is therefore [begin confidential] [REDACTED] [end confidential] or approximately 40% of available transmit power. (Rows AA and AB)

Table 3. Impact of Access Point Interference on Satellite RF Power

Ref.	Parameter	U-NII-2A rules		Note
A	Received Power Density of Single UNII access point	-192.4	dBW/MHz	Table 1 Row K
B	Expected devices in 20 MHz U-NII channel	1,100,000	devices	Table 1 Row N
C	Expected devices in 20 MHz U-NII channel	60.4	dB devices	
D	Received Interference Power	-132.0	dBW/MHz	
E	Satellite Uplink Receive Antenna Gain	6.37	dB	Globalstar FCC filing
F	Satellite Line Loss	-2.60	dB	Globalstar FCC filing
G				
H	Received Wi-Fi interference power@LNA = D+E+F	-128.23	dBW/MHz	
I	Nominal Transponder Gain	122.7	dB	Globalstar FCC filing
J	TX Line loss	-2.10	dB	Globalstar FCC filing
K	Transmitted WiFi interference power per chl	‡ [REDACTED] ‡	dBW/MHz	
L	Transmitted WiFi interference power per MHz	‡ [REDACTED] ‡	Watts	
M	Satellite transmitted interference power in 80 MHz (53 channels)	‡ [REDACTED] ‡	watts	
N				
O	Satellite Peak Power	‡ [REDACTED] ‡	Watts	
P	% Satellite power capacity wasted by amplifying interference	15%		
Q				
R	% Satellite Overhead Power (CDMA downlink overheads)	15%		
S	Satellite power overheads (CDMA)	‡ [REDACTED] ‡	Watts	
T	New power overhead	‡ [REDACTED] ‡	Watts	
U	Total Nominal Satellite power (including eclipse)	‡ [REDACTED] ‡	Watts	
V	Available Satellite Power for RF transmission	‡ [REDACTED] ‡	Watts	
W	Wasted Available power due to interference	‡ [REDACTED] ‡	Watts	
X	Wasted Available power due to interference	28.7%		
Y	Additional % power to increase transmit power by (0.55 dB)	12%		
Z	Additional power to increase transmit power	‡ [REDACTED] ‡	Watts	
AA	Total lost power available for RF (user transmissions)	‡ [REDACTED] ‡	Watts	
AB	Total lost power available for RF (user transmissions)	40.5%		

‡ = begin/end confidential

A comparison of the Globalstar satellite power allocation budget without and with unlicensed access point interference is illustrated in Figure 6 below. The available transmit power is reduced [begin confidential] [REDACTED], [end confidential] a significant reduction of 40.5%. The reduced power available for transmitting directly reduces the number of users that can be supported by the satellite.

[begin confidential]



[end confidential]

Figure 6. Degradation in Satellite RF Power Available to Users Due to Access Point Interference

If the degradation in CDMA overhead signal-to-noise ratio is *not* compensated for by an increase in transmitted CDMA overhead power, then an unavoidable power and capacity reduction of [begin confidential] [REDACTED] [end confidential] or 37% is still incurred by the downlink amplification of the increased interference present on the uplink, and automatic power increase in the user channels.³¹ This capacity reduction causes increased “system busy” indications to

³¹ Since the Globalstar CDMA downlink employs closed-loop power, the downlink power to the users is automatically increased to compensate for the increased overall interference-plus-noise in order to maintain user link quality. The mechanism for increasing the downlink satellite individual user powers is to increase the individual user powers on the feeder uplink. Since the satellite transponder applies a constant gain, the result is to increase the downlink user power correspondingly.

Globalstar users. The amount of additional RF power needed to maintain the geographic service availability is [begin confidential] [REDACTED] [end confidential] or another 3.5% of RF power and capacity lost.

This calculation of the unlicensed access point interference on satellite RF power does not take into account the time-varying nature of the DC power available at the satellite due to the sun being eclipsed at the satellite by the earth for 30 minutes of its 114 minute orbital period (25% of the time). If the peak interference and concomitant wasted RF power were to occur when the satellite is eclipsed, satellite operation could be further compromised.

Variation of Impact with Number of Access Points and Access Point Operational Characteristics

Figure 7 illustrates the relative satellite RF power available, and relative user capacity, as a function of the number of unlicensed access points in operation, for various unlicensed access point operational parameters, assuming that geographic availability of service is maintained. Curve (a) shows the degradation in available power and capacity for access points with 100% duty cycle, 6 dB antenna gain loss, and no clutter. Curve (b) shows the capacity loss for access points operating at an 80% duty cycle, and no clutter. The capacity reduction is 35% for 1.1 million access points in a 20 MHz IEEE 802.11ac channel.

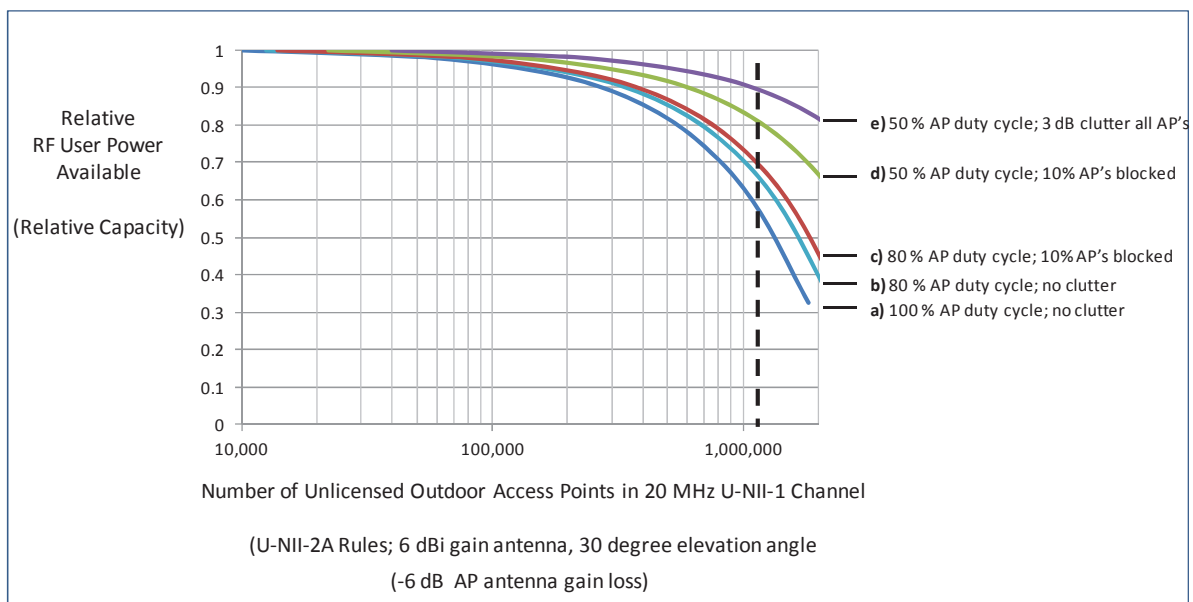


Figure 7. Degradation in RF User Power Available Due to Unlicensed Access Point Interference, as a Function of Number of Access Points and Access Point Parameters

Even if the number of access points that are completely blocked to the satellite due to clutter/shadowing is 10%, a much higher number than measurements to vehicles indicate, the capacity degradation is approximately 30%, as shown in curve (c). Curve (d) shows that if the access points' duty cycle is 50%, and 10% of them are blocked due to clutter/shadowing, then the capacity reduction is 20% for 1.1 million access points. For access points with a 50% duty cycle, an unlikely low value for busy hour operation, and with a 3dB clutter factor applied, the capacity degradation for 1.1 million outdoor access points is still 10%.

Unavoidable Impact on RF Power Available and Capacity

Figure 8 is a plot of the unavoidable RF satellite power and capacity lost due to re-transmitting the unlicensed access point interference on the satellite-to-user handheld device on the downlink and the automatic increase in user power resulting from closed-loop power control, as a function of the number of unlicensed access points, for access points with different parameters. Curve (a) is the degradation assuming that geographic service availability is maintained by increasing CDMA overhead power by network management intervention. 1.1 million access points operating at a 100% duty cycle and with no clutter cause a 40.5 % reduction in capacity. Curve (b) is the unavoidable capacity degradation due to retransmitting the unlicensed access point interference power and automatic increase in user power due to CDMA closed loop power control. 1.1 million access points cause an unavoidable 37% reduction in user capacity. A reduction of capacity during the busy hour would be evident to users whose call attempts would receive a "busy" signal or "failed call" indication. Curve (c) plots the unavoidable reduction in capacity, for access points with an 80% duty cycle, and 20% of the access points blocked due to urban area shadowing. An unavoidable 25% capacity reduction occurs in this case, a significant degradation.

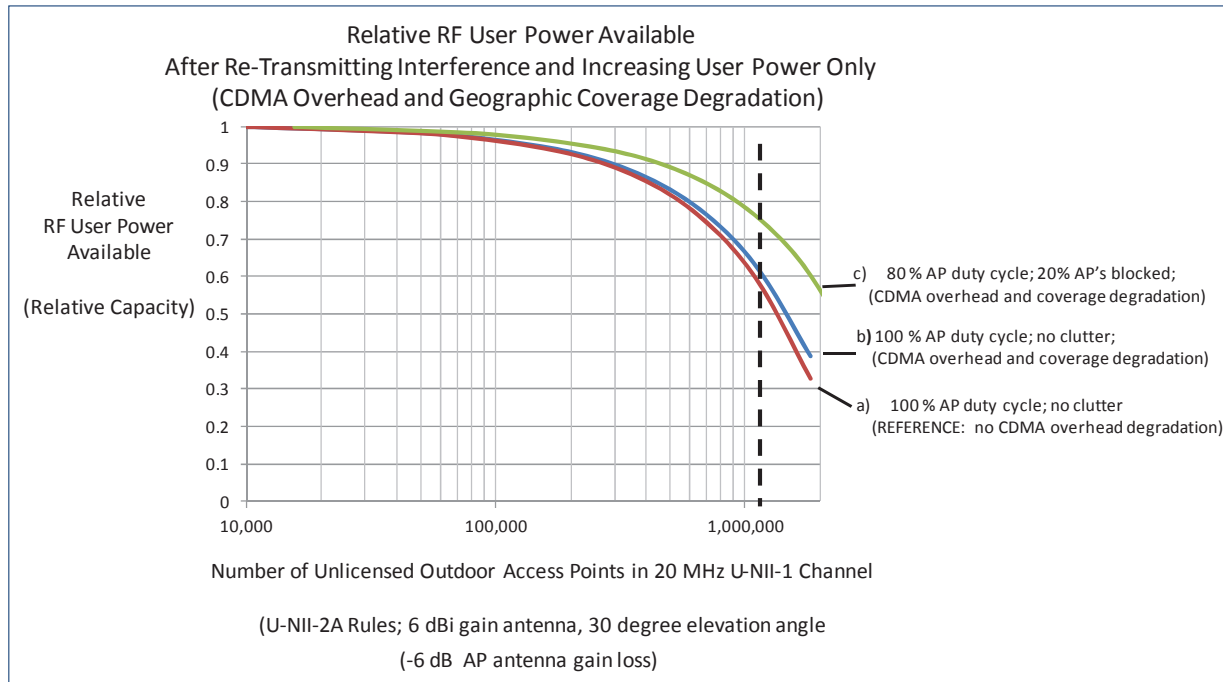


Figure 8. Relative RF User Power (Capacity) as Function of the Number of Access Points after Re-Transmitting Interference and Increasing User Power Only

3.7 Impact on Globalstar Geographic Service Availability

The previous sections have considered the negative impact of additional interference due to unlicensed wireless operations on Globalstar downlink capacity, with the assumption that the user quality of service as measured by geographic service availability (and call completion rate) is maintained. In Section 3.5, the quality of service is maintained by decreasing the user capacity and corresponding CDMA inter- and intra-beam interference in the downlink, in order to compensate for the increased interference due to unlicensed access points. In Section 3.6, the geographic availability of service is maintained by directly increasing the CDMA overhead transmitted power, which also reduces the capacity since less power is available for distributing among the Globalstar users. The unavoidable negative impact on RF power available (and capacity) was also analyzed for the case where CDMA overhead power was not adjusted, allowing the geographic service availability to degrade.

If the negative impact of additional uplink interference is not compensated for, and user capacity is maintained, then the overall downlink $E_b/(N_o+I_o)$ for the CDMA paging, synchronization, and pilot channels received by the Globalstar handhelds will be degraded due to the interference power of the unlicensed access points. This degradation will cause a reduction in the signal-to-noise-plus-interference power required to compensate for statistical variations in received signal strength due to signal fading and shadowing, resulting in a) an increase in the geographic area outages (increase

in “no service available” indication by the user); and b) an increase in dropped calls. Previous studies of non-geostationary satellite coverage can be used to estimate the effect on Globalstar coverage reliability.³² An overall downlink degradation of 0.5 to 1 dB, which is the expected range of the overall downlink degradation calculated in Tables 1 and 2, would increase service area outages by 5%, a noticeable amount. This is equivalent to decreasing the geographic availability of the Globalstar service by 5%. This level of degradation has been confirmed by internal Globalstar network analysis modeling.

Figure 9 below illustrates qualitatively the negative impact of degraded signal-to-noise-plus-interference on the Globalstar downlink, due to unlicensed access point interference on the Globalstar feeder uplink. The service area of the Globalstar satellite downlink beams is decreased, and there is an increase in the service area outage areas within the beam footprint.

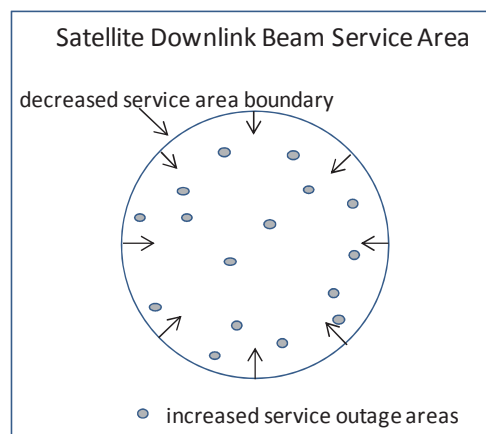


Figure 9. Qualitative Illustration of Impact of Degraded Signal-to-Noise-plus-Interference on Globalstar Downlink.

4.0 Critique of NCTA Analysis

The NCTA has put forth an analysis of the impact of potential U-NII-1 rule changes on Globalstar operations in recent submissions to the FCC.³³ This section contains a critique of the calculation method and parameters used in this analysis. Errors in the calculation method are identified and their effect on the NCTA claim of the number of unlicensed access points that can be tolerated is described. A corrected link budget analysis is shown that also uses typical rather than “minimum

³² See Giovanni E. Corazza and Francesco Vatalaro, “A Statistical Model for Land Mobile Satellite Channels and Its Application to Nongeostationary Orbit Systems,” *IEEE Transactions on Vehicular Technology*, Vol. 43, No. 3, August, 1994, Figure 1, p. 739.

³³ See *Attachment to ET Docket No. 13-49, Reply Comments of the National Cable & Telecommunications Association*, July 24, 2013.

interference” assumptions for the access point parameters. An assessment is made of the NCTA Globalstar uplink degradation that is alleged to be able to be tolerated.

4.1 NCTA Link Budget Calculation Critique

The NCTA link budget analysis is reproduced with annotations in Table 4 below. The NCTA analysis attempts to show that the number of unlicensed access points that can be tolerated by Globalstar if U-NII-2A rules are introduced into the U-NII-1 band is extremely large (several billion), if a newly proposed interference criterion of a 0.1 dB rise in the end-to-end (downlink) C/N ratio is accepted.

Review of the NCTA link budget calculation, however, reveals the following calculation/method errors :

- 1) Row N. Incorrect calculation of interference level from proposed allowable noise rise.

The following equation is properly used to calculate the power spectral density of the Interference that causes an increase of $Rise_{dB}$ in the noise with power spectral density N

$$I_{dBW/MHz} = N_{dBW/MHz} + 10 \log \left(10^{Rise_{dB}/10} - 1 \right)$$

- 2) Row Q. Incorrect interference calculation results in error in calculation of number of access points tolerated.
- 3) Row W. Incorrect calculation of the effect of number of access points with 20 MHz bandwidth on uplink interference spectral density, resulting in significant overestimate of number of access points (76 million compared to 1.9 billion) that can be tolerated with the proposed level of allowable noise rise.

Corrections to these errors are made in the “corrected calculation column”.

Result: With these corrections, the number of access points that could be tolerated with relaxed uplink interference value is several orders of magnitude less than the NCTA result. (76 million compared to 1.9 billion.) The number of access points that can be tolerated is still erroneously large due to unrealistic access point assumptions that minimize the interference levels. These assumptions are addressed in the following section.

Table 4. NCTA Calculation with Errors Noted and Corrections Made

	Parameter	NCTA Calculation	Corrected NCTA Calculation	Dimension	Comment
Ref	90 deg. Elevation angle	U-NII-2A outdoors	U-NII-2A outdoors		
A	output power/20 MHz	26	26	dBm	
B		-4	-4	dBW	
C		0.0199	0.0199	W/MHz	
D	power density	-17	-17	dBW/MHz	
E	building penetration loss	0	0	dB	
F	off-axis antenna gain reduction	15	15	dB	
G	avg clutter loss at 90 deg.	0	0	dB	
H	power received from single U-NII-1 device	-201.8	-201.8	dBW/MHz	
I	power received from single U-NII-1 device	-200.9	-200.9	dBW/1.25 MHz	
J					
K	[noise floor (satellite uplink)]	-140.6	-140.6	dBW/1.25 MHz	
L	NCTA assumed Noise rise = $(I+N)/N$	4.45	4.45	dB	
M	new N sys [= $(I+N)$]	-136.2	-136.2	dBW/1.25 MHz	
N	[implied interference = I]	-136.2	-138.1	dBW/1.25 MHz	NCTA incorrectly calculates interference from the noise rise
O					
P	delta (dB devices) = $\text{Row}(N) - \text{Row}(I)$	64.7	62.8		
Q	number devices full duty cycle	2,956,451	1,905,461		NCTA erroneously calculates (overestimates) the number of devices that can be tolerated
S					
T	number devices 10% duty cycle	29,564,510	19,054,607		
U	number 1.25 MHz channels in [80 MHz]	65			NCTA erroneously calculates effect of Access Points with 20 MHz bandwidth
V			4		Number of 20 MHz access point channels in 5170-5250 MHz
W	total number U-NII-1 devices (10% duty cycle) tolerated in 5170-5250 MHz	1,924,772,940	76,218,429		NCTA significantly overestimates the number of devices that could be tolerated
X					
Y	Comparison to ITU-R Recommendation				
Z	Interference ITU-R Rec. 1426 (dBW/1.25 MHz)	-159.4	-159.4	dBW/1.25 MHz	
AA	Interference Increase over ITU-R Rec.1426 (dB)	23.2	21.3	dB	NCTA would allow for a significant increase in interference over ITU-R recommendation
AB	Interference Increase over ITU-R	~200x	~125x		

4.2 NCTA Analysis Revisited

In Table 5, below, the NCTA analysis has been redone with more realistic access point parameters, and the calculation corrections have been applied to resolve errors identified in section 4.1. The access point parameters are the same ones used in Section 3: 6 dB relative loss for the access points' antenna due to a 30 degree elevation angle to the satellite, and 100% access point duty cycle.³⁴

Table 5. NCTA Link Budget Revisited with Likely Unlicensed Access Point Parameters

	Parameter	Original NCTA Calculation	Corrected NCTA with practical parameters	Dimension	Comment
Ref		U-NII-2A outdoors	U-NII-2A outdoors		
A	output power/20 MHz	26	30	dBm	EIRP with 6 dBi antenna
B		-4	0	dBW	
C		0.0199	0.0500	W/MHz	
D	power density	-17	-13	dBW/MHz	
E	building penetration loss	0	0	dB	
F	antenna gain reduction (90 degree elevation angle)	15	6	dB	30 degree elevation angle
G	avg clutter loss at 90 deg.	0	0	dB	
H	power received from single U-NII-1 device	-201.8	-192.8	dBW/MHz	
I	power received from single U-NII-1 device	-200.9	-191.9	dBW/1.25 MHz	
J	[path loss]	169.8	173.8		path loss for 30 degree elev angle
K	[noise floor (satellite uplink)]	-140.6	-140.6	dBW/1.25 MHz	
L	NCTA assumed uplink Noise rise = $(I+N)/N$	4.45	4.45	dB	Tolerated level proposed by NCTA
M	new N sys [= $(I+N)$]	-136.2	-136.2	dBW/1.25 MHz	
N	[implied interference = I]	-136.2	-138.1	dBW/1.25 MHz	NCTA incorrectly calculates the Interference from the noise rise. Correction applied in right hand column
O					
P	delta (dB devices) = Row(N) - Row(I)	64.7	53.8		
Q	number devices full duty cycle in single 20 MHz channel	2,956,451	240,453		Significantly fewer devices can be tolerated with practical access point parameters and accurate calculations.

Result: Using realistic, not minimum interference, unlicensed access point deployment and operational parameters, the number of unlicensed access points that are claimed to be tolerated using the NCTA proposed interference criteria (4.45 dB rise in the satellite uplink noise floor and

³⁴ Access point utilization varies significantly according to human activity cycles over the course of the day. There will be periods of the day when the access point utilization is at or near 100%, even though the utilization averaged over a 24 hour period is much less. The appropriate method of calculating the impact of interference due to unlicensed access points is to consider the time of day when activity is highest, since those are the times when Globalstar operations will be impacted.

causing a 0.1 dB degradation in total CDMA downlink) is only 240,000 in a single 20 MHz wide access point channel—significantly less than the 2.9 million resulting from the erroneous NCTA analysis, and also significantly less than the 1.9 million in the corrected NCTA analysis with minimum interference assumptions.

240,000 access points is significantly less than the 1 million devices that are expected to operate in a single 20 MHz access point channel. Even with the relaxed interference criteria proposed by the NCTA (compared to the ITU-R recommendation) the expected number of access points could not be tolerated.

4.3 Critique of NCTA's Spectrum Efficiency Theory

NCTA argues that the spectrum efficiency of a terrestrial, unlicensed, broadband wireless access service in the U-NII-1 spectrum is greater than that of a ubiquitous, mobile satellite service. This assertion is incorrect. The geographic reach and utility of Globalstar's service is fundamentally different from a terrestrial-based service, and this satellite service has end-user value that cannot be measured by a one-dimensional spectrum efficiency metric. Previous FCC study establishes that the value or utility provided by fundamentally different wireless services cannot be assessed by a single metric.³⁵ Since Globalstar is licensed to provide its service in the U-NII-1 band, there is no merit to the argument that (i) the interference protection afforded to this service can be relaxed, (ii) an uncontrolled number of unlicensed, interfering devices can be introduced, and (iii) the capacity and quality of Globalstar's licensed satellite service can be degraded.

³⁵ "Satellite systems encompass a significant diversity of service types such that it is difficult and not necessarily meaningful to establish a single spectrum efficiency metric that would apply to all service types." See *FCC Technological Advisory Council, Sharing Work Group White Paper: Spectrum Efficiency Metrics*, Sep 25, 2011, p. 5.

5.0 Conclusions

5.1 Impact to Globalstar's Licensed Operations of Potential Rule Changes to U-NII-1 Rules

The introduction of additional interference in the Globalstar uplink due to outdoor unlicensed access point operations destroys the balance between the performance requirements and operational constraints of RF power transmitted to the user devices; RF satellite power available for user communications; uplink and overall RF signal-to-noise-plus-interference; geographic service availability; and user capacity. User capacity and geographic service availability cannot be maintained with the addition of the planned number of outdoor unlicensed access points in the U-NII-1 band operating with relaxed transmission requirements.

The following is a summary of the analysis of the impact to Globalstar that would result if the proposed rule changes to align with the U-NII-2A band or U-NII-3 band were to be put in place, and 1.1 million outdoor access points with the reference characteristics operate in each of the 20 MHz IEEE 802.11ac channels in the U-NII-1 band:

1. Alignment of U-NII-1 rules with U-NII-2A rules and allowing outdoor operation:
 - a. Results in interference levels to the Globalstar gateway to satellite uplink that would increase the noise floor by 27 dB higher than ITU-R S.1426 recommendations, when the planned extensive deployment and use of unlicensed wireless internet access points takes place.
 - b. Causes an *unavoidable* 37% decrease in Globalstar user capacity due to reduced satellite RF power available to users, caused by automatic retransmitting of the uplink interference power, and inherent operation of the CDMA closed loop power control that automatically increases the user power to maintain call quality. Globalstar users would experience system "busy" indications during peak usage periods.
AND
 - c. Degrades geographic service availability by 5%, resulting in failed call attempts due to the degraded signal-to-noise-plus interference of the downlink CDMA overhead channels (pilot, paging, and synchronization channels)
OR
 - c.1 Degrades capacity by an additional 3.5% (to 40.5%) by increasing CDMA overhead power to maintain geographic service availability.
OR
 - c.2 Degrades capacity directly by an additional 19% (to 56%) if satellite intra-beam and inter-beam interference is reduced to maintain geographic service availability.

2. Aligning U-NII-1 rules with U-NII-3 rules and allowing outdoor operation:
 - a. Causes interference levels in the Globalstar gateway to satellite uplink that would increase the noise floor by 33 dB higher than ITU-R recommendations, if the envisioned extensive deployment and use of unlicensed wireless internet access points takes place.
 - b. Causes an unavoidable, >37% decrease in user capacity caused by automatic retransmitting of the uplink interference power, and inherent operation of the CDMA closed loop power control that automatically increases the user power to maintain call quality. Globalstar users would experience system “busy” indications during peak usage periods.
AND
 - c. Degrades geographic service availability by >5%, resulting in failed call attempts due to the degraded signal-to-noise-plus interference of the downlink CDMA overheads (pilot, paging, and synchronization channels)
OR
 - c.1 Degrades capacity by > 41% by increasing CDMA overhead power to maintain geographic service availability.
OR
 - c.2 Degrades capacity directly by > 56% if satellite intra-beam and inter-beam interference to maintain geographic service availability.

5.2 NCTA Analysis

The NCTA analysis previously submitted contains several method and calculation errors that undermine the stated conclusions.

The method and calculation errors include:

1. Erroneous calculation of the interference power from the noise rise.
2. Erroneous calculation of the aggregate effect of unlicensed access points with 20 MHz IEEE 802.11ac bandwidth on the Globalstar uplink and CDMA downlink channels.
3. Incorrect calculation of the number of access points that can be tolerated with the proposed interference tolerance level.
4. Failure to evaluate the effect of uplink interference on the downlink CDMA capacity.
5. Failure to evaluate the effect of uplink interference on satellite power.

In addition, the NCTA analysis uses assumptions for the unlicensed access point parameters that are unlikely to be encountered in actual deployment: These include:

1. Estimating the access point duty cycle at 10%, which is not reasonable for busy-hour operation.
2. Using a 15 dB decrease in access point antenna gain, due to assuming 90 degree elevation angle from access point to satellite. A 6-9 dB decrease in access point antenna gain is more likely, given a 30 degree elevation angle to the satellite.

The result of these errors is that the NCTA analysis significantly overestimates the number of unlicensed wireless LAN access points that could be tolerated.

5.3 Recommendation

U-NII-1 band rules should not be changed to allow outdoor operation as currently permitted under U-NII-2A or U-NII-3 rules, since the likely harmful impact on Globalstar licensed operations is significant. The minimum negative impact on Globalstar capacity is 37%, resulting from the mere introduction of interference due to the planned number of outdoor unlicensed access points in the U-NII-1 band, and the automatic increase in downlink user power caused by CDMA closed loop power control, without any compensation by Globalstar to increase the CDMA paging, pilot, and synchronization channels to maintain geographic service availability. There is no mechanism to limit the number of unlicensed wireless LAN access points in order to keep the potential interference below levels that would impact Globalstar operations.

Appendix A: U.S. Urbanized Areas and Expected Access Points

The following table, taken from 2010, US census data,³⁶ lists the urbanized areas according to their population area and their geographic area in square miles. A column has been added to indicate the corresponding geographic area in square kilometers. Using the deployment of wireless access points in Mountain View, CA as an example of how an unlicensed wireless internet access service could be deployed in an urbanized area,³⁷ the number of wireless access points for the top 41 urbanized areas, and the total number of wireless access points to cover the entire US urbanized area is shown.

³⁶ See *New US Urban Area Data Released*, newgeography, October 29, 2013, <http://www.newgeography.com/content/002747-new-us-urban-area-data-released>.

³⁷ See *Google WiFi*, http://en.wikipedia.org/wiki/Google_WiFi. 500 routers in Mountain View, CA have been deployed in an area of 31 sq km., or 16 routers per sq km; see also *The Future of Google WiFi*, https://support.google.com/wifi/answer/47607?hl=en&ref_topic=2603788, and *How Google WiFi Works*, https://support.google.com/wifi/answer/30814?hl=en&ref_topic=2603788.

Table 6. Hypothetical Number of Access Points in US Urbanized Areas

Rank	Urban Area	Population	Land Area (Square Miles)	Land Area (Sq km)	number of access points @ 16 /sq km
1	New York--New ark, NY--NJ--CT	18,351,295	3,450	8,970	143,520
2	Los Angeles--Long Beach--Anaheim, CA	12,150,996	1,736	4,514	72,218
3	Chicago, IL--IN	8,608,208	2,443	6,352	101,629
4	Miami, FL	5,502,379	1,239	3,221	51,542
5	Philadelphia, PA--NJ--DE--MD	5,441,567	1,981	5,151	82,410
6	Dallas--Fort Worth--Arlington, TX	5,121,892	1,779	4,625	74,006
7	Houston, TX	4,944,332	1,660	4,316	69,056
8	Washington, DC--VA--MD	4,586,770	1,322	3,437	54,995
9	Atlanta, GA	4,515,419	2,645	6,877	110,032
10	Boston, MA--NH--RI	4,181,019	1,873	4,870	77,917
11	Detroit, MI	3,734,090	1,337	3,476	55,619
12	Phoenix--Mesa, AZ	3,629,114	1,147	2,982	47,715
13	San Francisco--Oakland, CA	3,281,212	524	1,362	21,798
14	Seattle, WA	3,059,393	1,010	2,626	42,016
15	San Diego, CA	2,956,746	732	1,903	30,451
16	Minneapolis--St. Paul, MN--WI	2,650,890	1,022	2,657	42,515
17	Tampa--St. Petersburg, FL	2,441,770	957	2,488	39,811
18	Denver--Aurora, CO	2,374,203	668	1,737	27,789
19	Baltimore, MD	2,203,663	717	1,864	29,827
20	St. Louis, MO--IL	2,150,706	924	2,402	38,438
21	Riverside--San Bernardino, CA	1,932,666	545	1,417	22,672
22	Las Vegas--Henderson, NV	1,886,011	417	1,084	17,347
23	Portland, OR--WA	1,849,898	524	1,362	21,798
24	Cleveland, OH	1,780,673	772	2,007	32,115
25	San Antonio, TX	1,758,210	597	1,552	24,835
26	Pittsburgh, PA	1,733,853	905	2,353	37,648
27	Sacramento, CA	1,723,634	471	1,225	19,594
28	San Jose, CA	1,664,496	286	744	11,898
29	Cincinnati, OH--KY--IN	1,624,827	788	2,049	32,781
30	Kansas City, MO--KS	1,519,417	678	1,763	28,205
31	Orlando, FL	1,510,516	598	1,555	24,877
32	Indianapolis, IN	1,487,483	706	1,836	29,370
33	Virginia Beach, VA	1,439,666	515	1,339	21,424
34	Milwaukee, WI	1,376,476	546	1,420	22,714
35	Columbus, OH	1,368,035	510	1,326	21,216
36	Austin, TX	1,362,416	523	1,360	21,757
37	Charlotte, NC--SC	1,249,442	741	1,927	30,826
38	Providence, RI--MA	1,190,956	545	1,417	22,672
39	Jacksonville, FL	1,065,219	530	1,378	22,048
40	Memphis, TN--MS--AR	1,060,061	497	1,292	20,675
41	Salt Lake City--West Valley City, UT	1,021,243	278	723	11,565
Total		133,490,862	41,139	106,961	1,711,382
	Other Urban Areas	115,762,409	65,247	169,642	2,714,275
	Total Urban	249,253,271	106,386	276,604	4,425,658

Appendix B: Unlicensed Access Point Operational Parameters

B.1 Access Points Antenna Reference

Figure 10 provides a reference diagram for the wireless LAN access point parameters used in the link budget calculations.

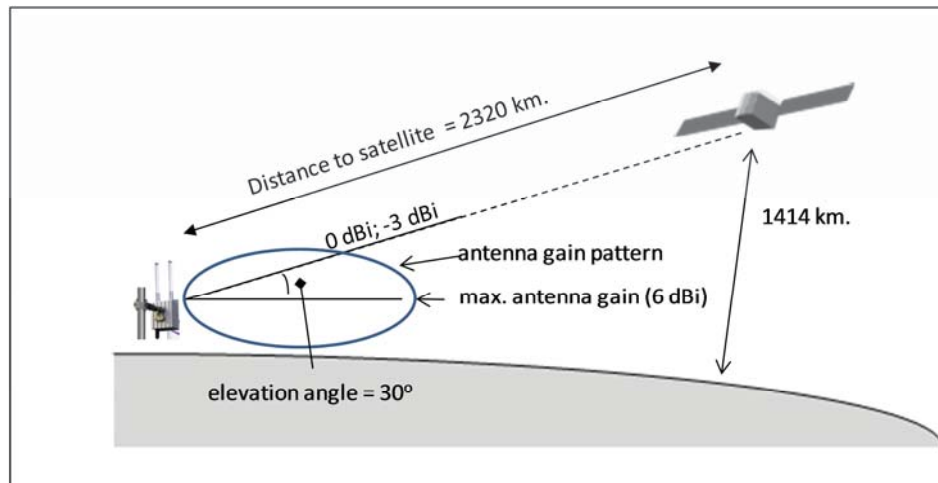


Figure 10: Access Point Reference

B.2 Access Point Duty Cycle

In order to ascertain likely duty cycles of wireless LAN access points, monitoring of the RF spectrum in the U-NII bands was performed during the day on October 1, 2013, using receiving antennas located on the roof of the 237 foot (22 story) Illinois Institute of Technology (IIT) Tower at 10 W. 35th Street in Chicago, IL. The location is approximately 4.5 miles directly south of the Chicago central business district.

Figure 11 indicates the location of the antennas on the roof of the IIT Tower.



Figure 11. Location of Monitoring Antennas at 10 W. 35th Street. View North.

Figure 12 is a spectrogram plot of the RF signals observed in the U-NII bands. In this plot, for the observation period of approximately 1 hour, a continuously operating, high duty cycle signal was observed in the U-NII-3 band. It was not able to be determined whether the signal was from a point-to-point link or point to multi-point link. While more comprehensive tests are required, it is likely that a high percentage of wireless LAN access points will eventually operate at a high duty cycle during busy periods.

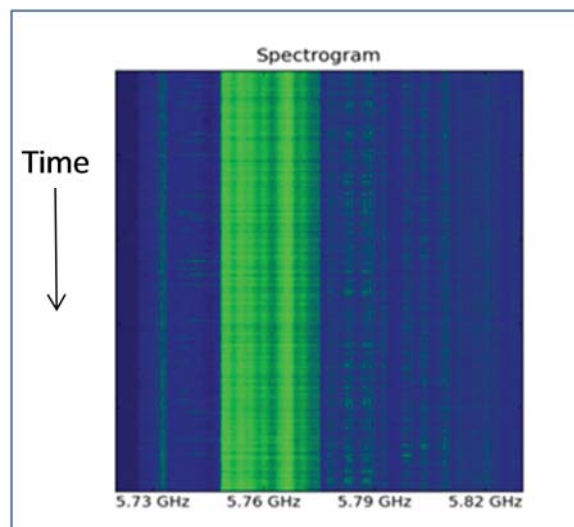


Figure 12. Spectrogram of U-NII-3 Band

B.3 Access Point Deployment

Figure 13 is an example of outdoor wireless LAN deployment on the Illinois Institute of Technology campus in Chicago, Illinois.



Figure 13. Outdoor Access Point Deployment

The access point antennas are located approximately 6 meters above sidewalk level. While shadowed to the east, the access point has a nearly clear line of sight in the direction of the photo over an azimuthal angle of nearly 135 degrees (directly south to northwest).

Appendix C: Impact of Access Point Interference on CDMA Downlink Capacity

C.1 Interference Characterization in the Globalstar CDMA Downlink

In the Globalstar CDMA downlink channels, multiple individual users share the same CDMA channel within a satellite beam using orthogonal codes. Adjacent satellite downlink beams re-use identical CDMA channels (frequencies) from beam to beam (single frequency re-use). The downlink capacity is therefore limited primarily by three factors: 1) the power available in the satellite for distribution to the individual CDMA users and channels; 2) the co-channel interference in a beam caused by co-channel CDMA users in adjacent beams, and 3) adjacent-channel interference caused by CDMA users in the same beam.

Co-channel and adjacent channel interference scenarios in the Globalstar CDMA downlinks are illustrated in Figure 14. The roughly trapezoidal-shaped and circular regions are the satellite-to-mobile user device downlink beams for individual satellites in the Globalstar constellation. Adjacent channel interference occurs primarily within a downlink beam, while co-channel interference occurs between adjacent beams and adjacent satellites, as shown in the Figure.

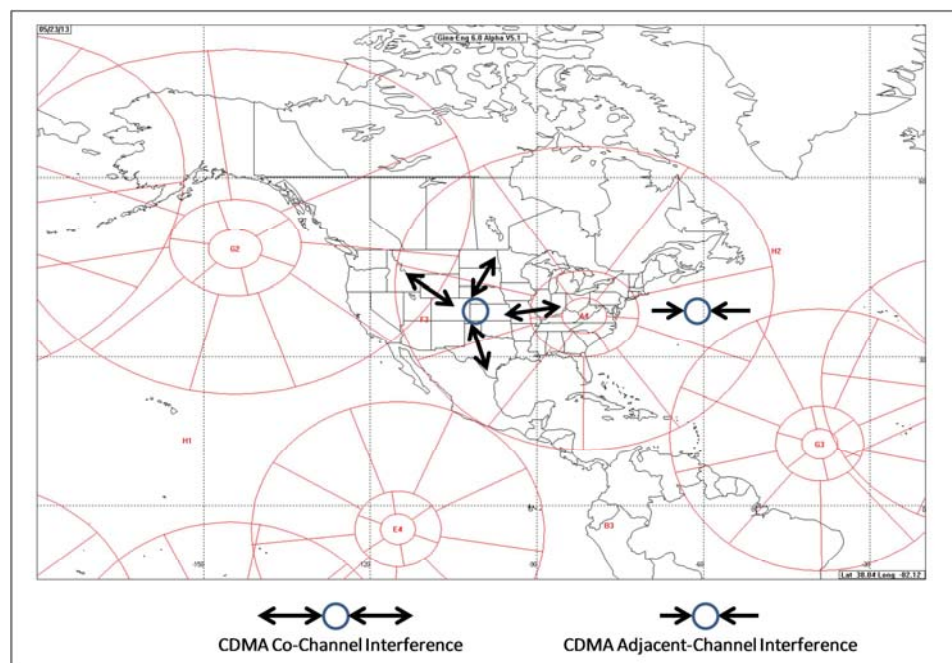


Figure 14. Illustration of Inherent CDMA Downlink Interference

Since the power available at the satellite is fixed, degradation in the overall Globalstar downlink CDMA channels cannot be remedied without impacting capacity or communication link geographic coverage reliability. In order to estimate the impact of overall downlink channel degradation on

Globalstar performance, we assume that the transmit power available at the satellite for the downlink is fixed. Keeping geographic coverage reliability (geographic availability of coverage to the end user) constant, any overall downlink increase in interference due to external sources (for example, unlicensed access points in the ground station to satellite feeder link) must then be compensated by a reduction in the inherent CDMA co-channel and adjacent channel interference on the downlink. Since the inherent CDMA co-channel and adjacent channel interference is directly related to the number of co-channel and adjacent channel users, the capacity reduction of the Globalstar CDMA downlink can be estimated by calculating the reduction in users needed to maintain acceptable $E_b/(N_o + I_o)_{ovr}$ on the downlink, where I_o is the resultant total interference inherent to CDMA, plus the interference due to external sources.

C.2 Detailed Calculation of Relative Capacity

The following table illustrates the calculation of CDMA capacity as a function of the number of unlicensed wireless LAN access points operating in a 20 MHz channel bandwidth, as described in Section 3.5 and plotted in Figure 5.

Table 7. Calculation of Relative Capacity as a Function of Number of Access Points

Number of Access Points U-NII-2 Rules Outdoor (6 dB antenna elevation loss) in 20 MHz BW	Uplink Degradation (dB)	Uplink $E_b/(N_o + I_o + I_a)$ (dB)	Required Downlink $E_b/(N_o + I_o, red)$ (dB)	Overall $E_b/(N_o + I_o)$ (dB) Required [$E_b/(N_o + I_o)_{min}$]	Incr = Increase in downlink ($E_b/(N_o + I_o)$) needed to maintain $E_b/(N_o + I_o)_{MIN, ovr}$ (db)	I_o , downlink dBW/Hz	Reduces in Downlink I_o (dB) Required	Relative Capacity
-	0	19.9	1.063	1.01	0	-209.60	0.00	1
32,000	1	18.9	1.077	1.01	0.0145	-209.67	0.07	0.985
72,000	2	17.9	1.095	1.01	0.0325	-209.75	0.16	0.965
185,000	4	15.9	1.150	1.01	0.0875	-210.03	0.43	0.906
365,000	6	13.9	1.235	1.01	0.1725	-210.48	0.88	0.816
650,000	8	11.9	1.375	1.01	0.3125	-211.32	1.72	0.673
1,100,000	10	9.9	1.610	1.01	0.5475	-213.15	3.55	0.442
1,820,000	12	7.9	2.000	1.01	0.9375	-220.32	10.72	0.085

Appendix D: Company Profile

Profile: Roberson and Associates, LLC

Roberson and Associates, LLC, is a technology and management consulting company with government and commercial customers that provides services in the areas of RF spectrum management, RF measurements and analysis, and technology management. The organization was founded in 2008 and is composed of a select group of individuals with corporate and academic backgrounds from Motorola, Bell Labs, IBM, IITRI (now Alion), independent consulting firms, and the Illinois Institute of Technology. Together the organization has over 400 years of the high technology management and technical leadership experience with a strong telecommunications focus.

Profiles: Roberson and Associates, LLC, Staff

Dennis A. Roberson, President and CEO, Roberson and Associates

Mr. Roberson is the Founder, President and CEO of Roberson and Associates, LLC. In parallel with this role he serves as Vice Provost for Research and Research Professor in Computer Science at Illinois Institute of Technology where he has responsibility for IIT's corporate relationships including IIT's Career Management Center, Office of Compliance and Proposal Development, Office of Sponsored Research and Programs, and Technology Transfer efforts. He also supports the development and implementation of IIT's Strategic Plan, the development of new research centers, and the successful initiation and growth of IIT related technology-based business ventures. He is an active researcher in the wireless networking arena and is a co-founder of IIT's Wireless Network and Communications Research Center (WinCom). His specific research focus areas include dynamic spectrum access networks, spectrum occupancy measurement and spectrum management, and wireless interference and its mitigation and of which are important to the Roberson and Associates mission. He currently serves on the governing and / or advisory boards of several technology-based companies. Prior to IIT, he was EVP and CTO at Motorola and he had an extensive corporate career including major business and technology responsibilities at IBM, DEC (now part of HP), AT&T, and NCR. He is and has been involved with a wide variety of Technology, Cultural, Educational and Youth organizations currently including the FCC Technological Advisory Council (where he serves as Chair) and Open Internet Advisory Committee, the Commerce Spectrum Advisory Committee, and the Board of HCJB Global. He is a frequent speaker at universities, companies, technical workshops, and conferences around the globe. Professor Roberson has BS degrees in Electrical Engineering and in Physics from Washington State University and a MSEE degree from Stanford.

Kenneth J. Zdunek, Ph.D. –V.P. and Chief Technology Officer

Dr. Zdunek is Vice President and the Chief Technology Officer of Roberson and Associates. He has 35 years of experience in wireless communications and public safety systems. Concurrently he is a research faculty member in Electrical Engineering at the Illinois Institute of Technology, in Chicago, Illinois, where he conducts research in the area of dynamic spectrum access and efficient spectrum utilization, and teaches a graduate course in wireless communication system design. He is a Fellow of the IEEE, recognized for his leadership in integrating voice and data in wireless networks. Prior to joining Roberson and Associates, he was VP of Networks Research at Motorola, a position he held for 9 years. Dr. Zdunek was awarded Motorola's patent of the year award in 2002 for a voice-data

integration approach that is licensed and extensively used in GSM GPRS. He holds 17 other patents, included patents used in public safety trunked systems and cellular and trunked systems roaming. He directed the invention and validation of Nextel's iDEN™ voice-data air interface and IP based roaming approach, and was the principal architect of Motorola's SmartNet™ public safety trunking protocol suite. In the 1990's, he directed a Spectrum Utilization and Public Safety Spectrum Needs Projection submitted to the FCC in support of the 700 MHz spectrum allocation for Public Safety. He was awarded the BSEE and MSEE degrees from Northwestern University, and the Ph.D. EE degree from the Illinois Institute of Technology. He is a registered Professional Engineer in the State of Illinois. He is past president, and on the board of directors of the Chicago Public Schools Student Science Fair, Inc.

Roger Peterson, Ph.D., Senior Principal Investigator

Roger Peterson is a Lifetime Fellow of the IEEE and co-author of four text books on digital communications and spread spectrum technology. He has more than 30 years of experience in digital communications technology and has served as associate editor for spread spectrum for the *IEEE Transactions on Communications*. Prior to joining Roberson and Associates he was a Fellow of the Technical Staff at Motorola Labs where, most recently, he was responsible for system-level capacity analysis of relay-assisted WiMax systems. He is the author of numerous technical papers and holds six issued US patents. He received the BS, MS, and PhD degrees in electrical engineering from the Illinois Institute of Technology.